Discovery Potential through Searches

for the CDF and DØ Collaborations

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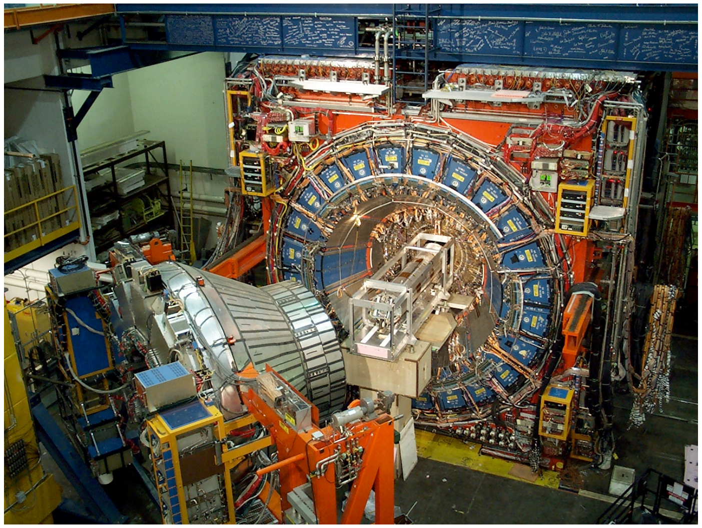
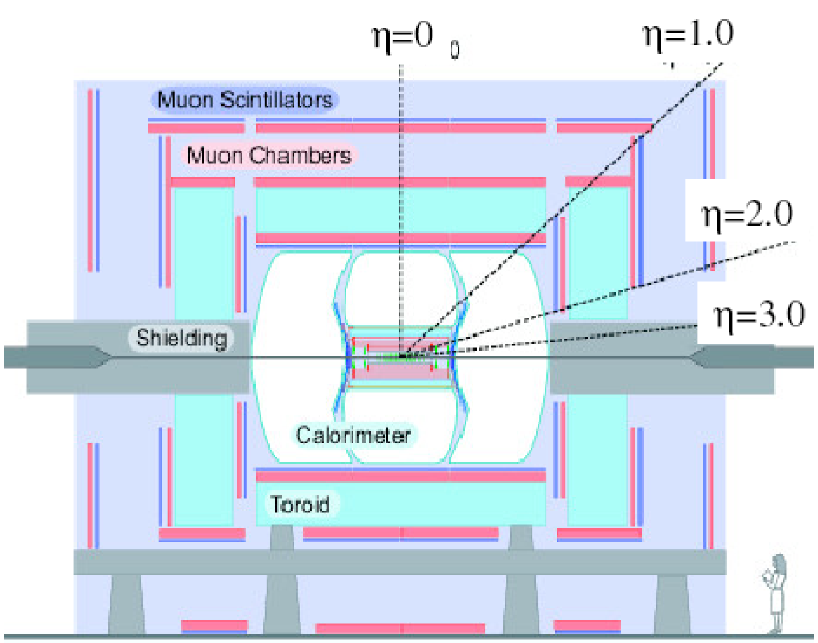
University of Liverpool

P5 meeting, Fermilab, 09/12/2005

CDF and DØ Detectors





- **Multi-purpose detectors:**
  - Calorimeter coverage up to $|\eta|<3$
  - Full tracking coverage up to $|\eta|<1$, limited up to $|\eta|<2.5$
  - Identify electrons/photons, muons, tau's, jets
  - precision vertexing and tracking, b-tagging
  - High performance DAQ and trigger systems
- **Have analysed about 300-600 pb^{-1}**
  - data taken until September 2004-March 2005

There are many open Questions...

- What is the origin of mass?
- Are there 3 generations? And if so, why?
- Why is there such a large mass hierarchy?
  - Within fermion sector
  - Between EWK and Planck scale
- What is cold dark matter?
- Is there a common single force?
- Are the fermions and bosons point-like? Or do they have substructure?
- Where has all the anti-matter gone?

...AND ABOUT AS MANY MODELS!

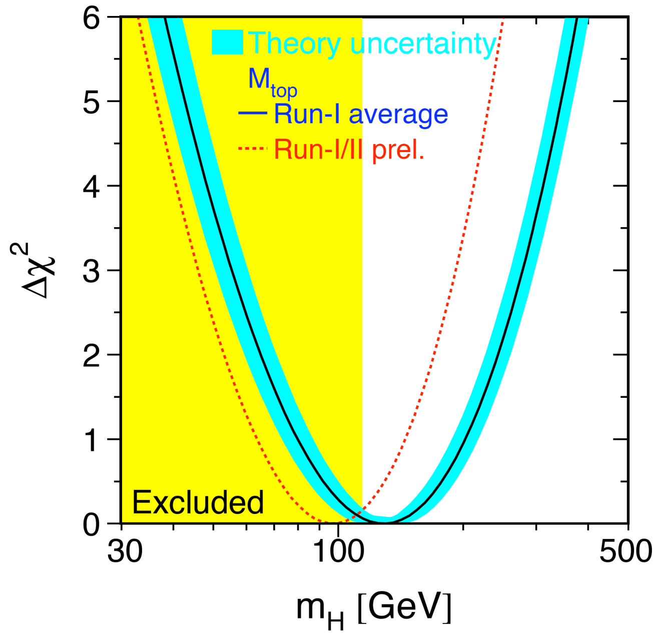
- Supersymmetry
  - mSUGRA, GMSB, AMSB, R-parity violated or not,...
- Extended gauge theories
- Little Higgs
- Technicolor, topcolor
- Compositeness: excited fermions, preons
- Extra dimensions (ADD, Randall-Sundrum)
- ...

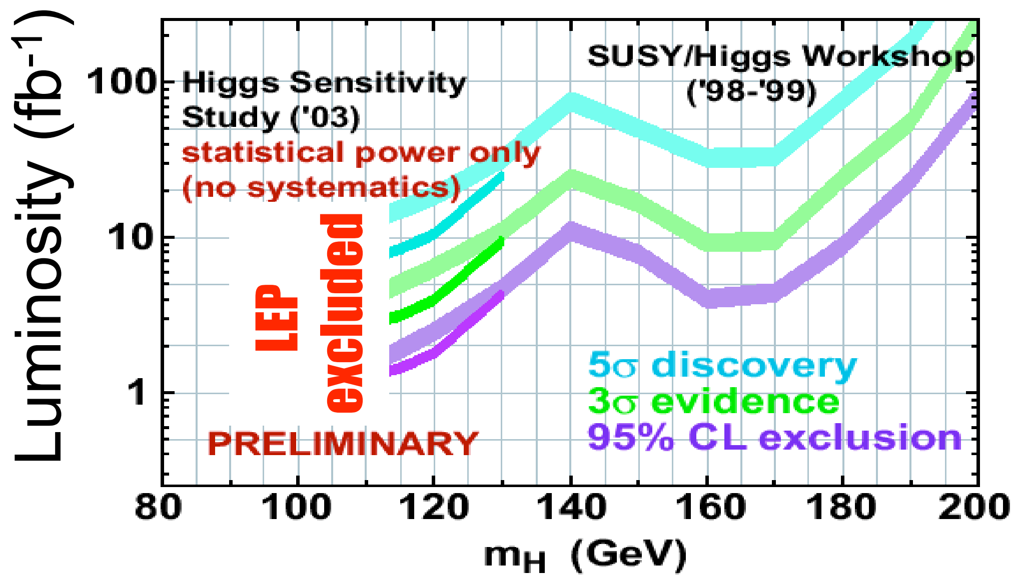
- All of which predict new particles to be discovered
- None of which may be true

Selected a Few Analyses

- Chosen the following topics because particularly well motivated theoretically:
  - Standard Model Higgs Boson
  - SUSY:
    - Higgs bosons
    - Charginos/neutralinos +squarks/gluinos
    - Rare decays
- But remember, we are experimentalists!
  - So, we keep an open eye as much as we can
  - We may find the unexpected which would be most exciting for our field

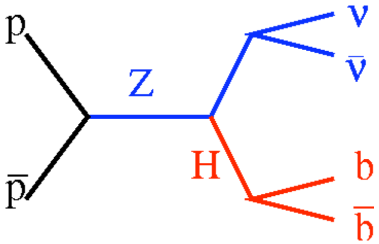
Standard Model Higgs Boson

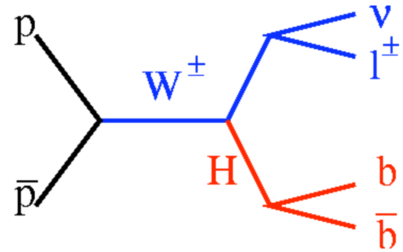


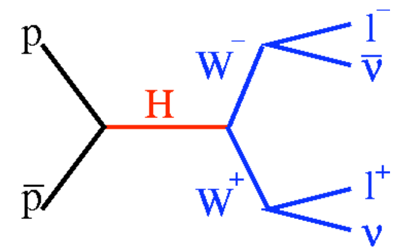


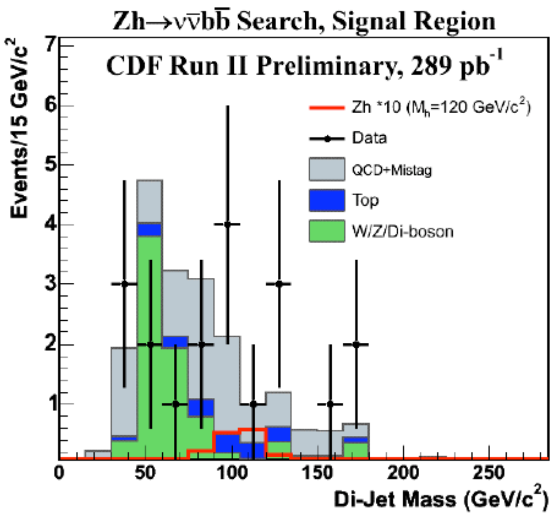
- **Only Standard Model particle not seen as yet:**
  - **understanding of electroweak symmetry breaking**
- **Precision data prefer light SM Higgs:** $M_{Higgs} = 91^{+45}_{-32}$ GeV
- **SUSY (MSSM) requires m_h<136 GeV/c^2**
- **Studies in 1999 and 2003 predicted Tevatron reach:**
  - **1.5–2.5 fb^{-1}: 95%CL exclusion at m_H=115 GeV/c^2**
  - **3–5 fb^{-1} : 3σ evidence at m_H=115 GeV/c^2**

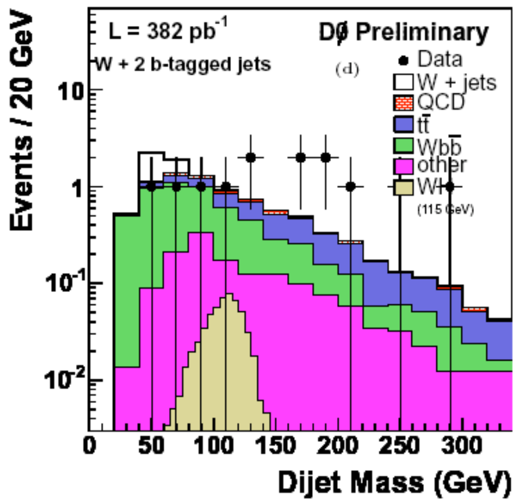
Some Recent Results by CDF and DØ

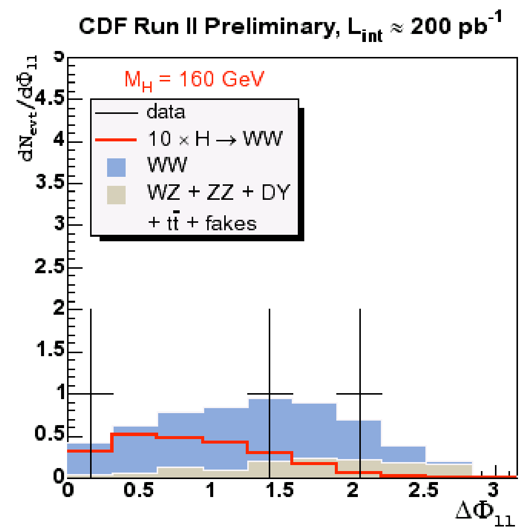








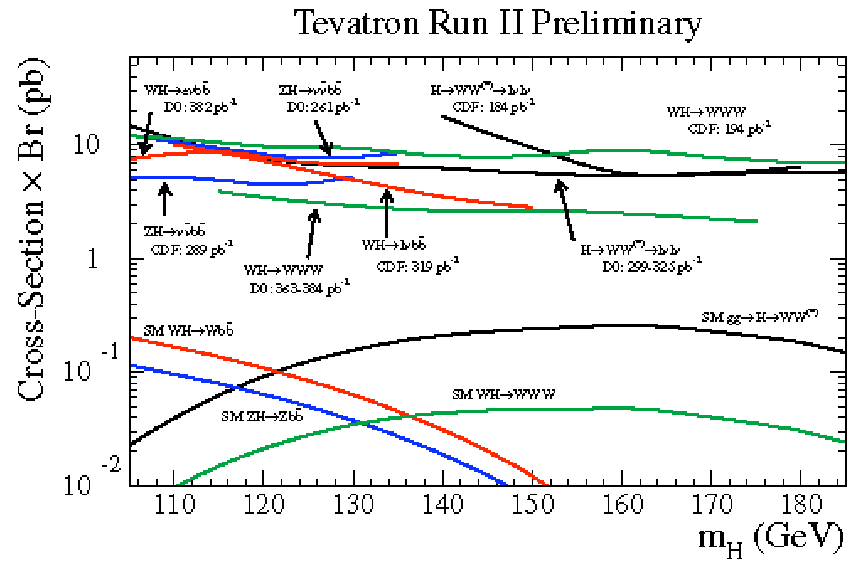


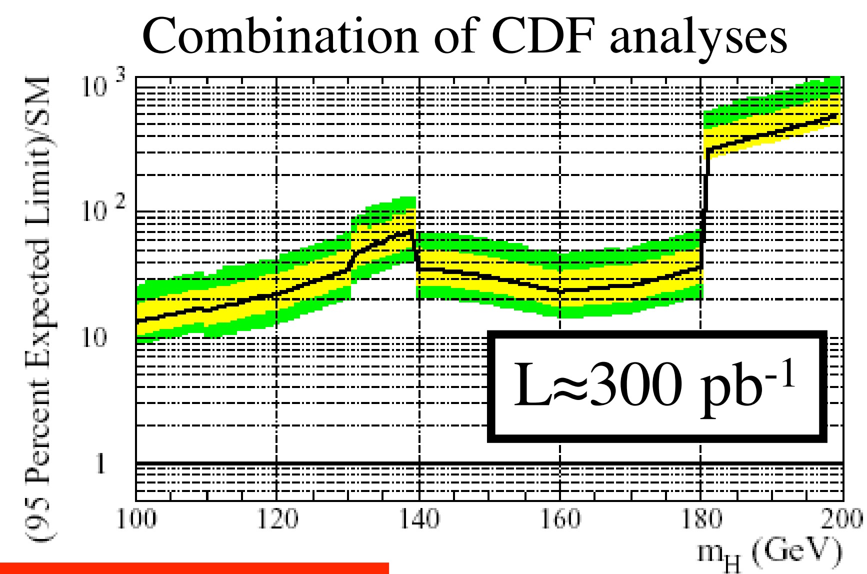


- **Low Mass, m_H<140 GeV/c²:**
  - **dominant decay into bb (~90%)**
  - **Search for peak in bb mass spectrum**
- **High mass, m_H>140 GeV/c²:**
  - **Dominant decay into WW (~90%)**
  - **Examine angular distributions of leptons**

CURRENT HIGGS SEARCH RESULTS

- Current results from DØ and CDF:
  - WH->lνbb, ZH->$\nu\nu$bb
  - WW->ll$\nu\nu$, WWW->l$^\pm$l$^\pm$ + X
- Combination of current CDF analyses (L=300 pb^{-1}):
  - upper limit 20 times larger than SM prediction at 115 GeV/c^2
  - Will gain
    - factor $\sqrt{2}$ from combination of CDF and D0
    - factor $\sqrt{(L/300\ \mathrm{pb}^{-1})}$ with increasing luminosity
  - factor 5 missing with L=2 fb^{-1}
- Are the 1999 and 2003 studies credible given the current performance?





Can we close the gap?

Can we close the Gap?

- Assume current analyses as starting point
  - Scale current systematic uncertainties by $1/\sqrt{L}$
- Reevaluated all improvements using latest knowledge

	Luminosity equivalent=$(S/\sqrt{B})^2$		
Improvement	WH->lvbb	ZH->vvbb	ZH->llbb
mass resolution	1.7	1.7	1.7
Continuous b-tag (NN)	1.5	1.5	1.5
Forward b-tag	1.1	1.1	1.1
Forward leptons	1.3	1.0	1.6
Track-only leptons	1.4	1.0	1.6
NN selection	1.75	1.75	1.0
WH signal in ZH	1.0	2.7	1.0
Product of above	8.9	13.3	7.2
CDF+DØ combination	2.0	2.0	2.0
All combined	17.8	26.6	14.4

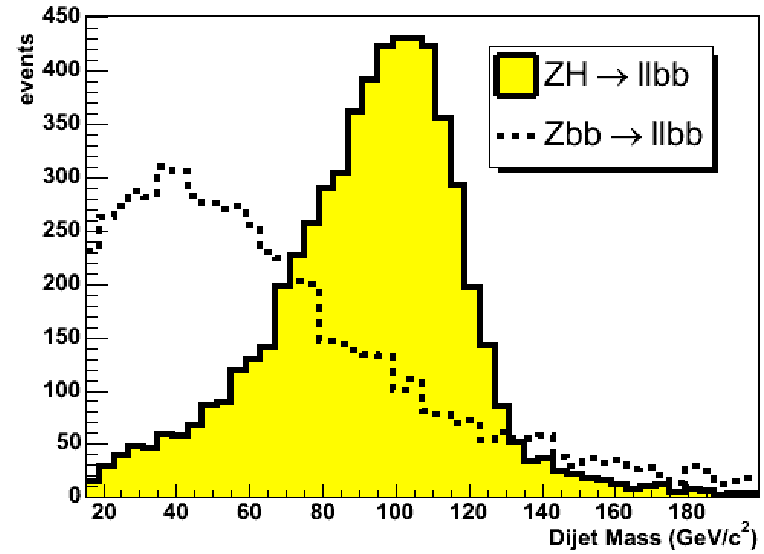
See talks by G. Blazey and Y.-K. Kim

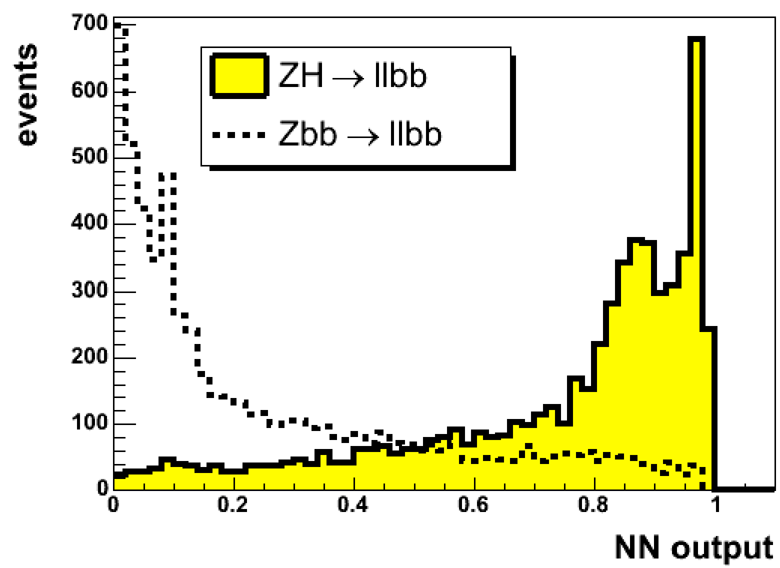
Expect factor ~10 improvements and CDF+DØ combination:

=> Need 2.5 fb^{-1} for 95%C.L. exclusion of 115 GeV Higgs

Neural Net Selection

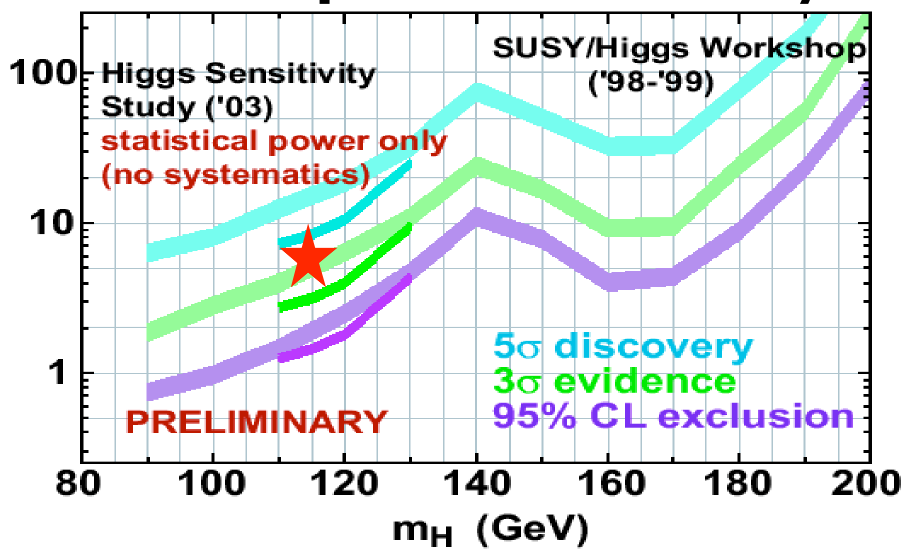
- **Neural Net:**
  - NN analysis done for ZH→llbb
  - 16 input variables
- **Improves S/√B by factor 1.44**
  - Mass cut : 100±20 GeV:
    - Signal ε =53.7%
    - Background ε =15.8%
  - NN cut >0.6
    - Signal ε=77.5%
    - Background ε=15.4%
  - Equivalent lumi=$(S/\sqrt{B})^2$=2
- **1.75 from 2003 HSWG study is achievable:**
  - Even gained factor 4 in $(S/\sqrt{B})^2$ in single top NN analysis!
    - see talk by J. Hobbs



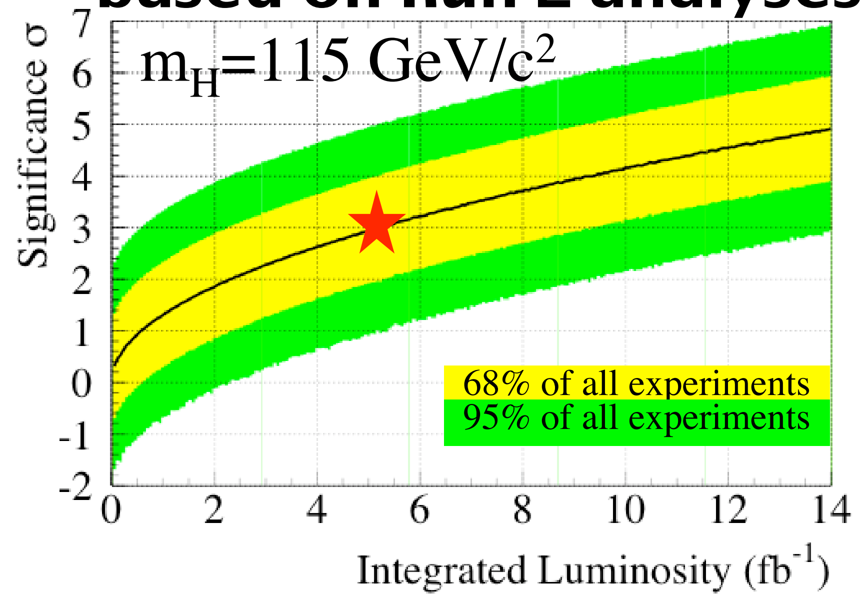


Higgs at Tevatron: Conclusions

based on pre-Run 2 analyses



based on Run 2 analyses



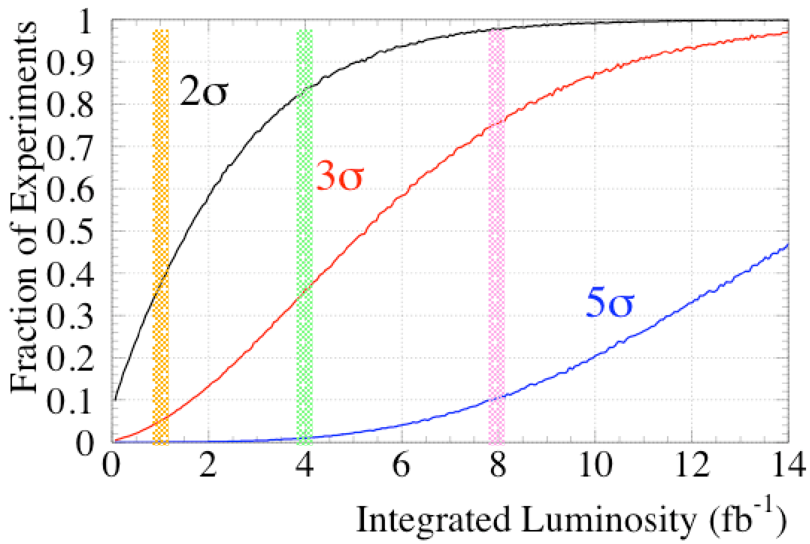
- **Confirmed previous studies with run 2 data experience**
  - **Syst. uncertainties increase required luminosity by 40%**
- **95% C.L. exclusion:**
  - **$\int Ldt$ =2–2.5 fb^{-1}: probe LEP excess at m_H=115 GeV/c^2**
  - **$\int Ldt$ =4.0 fb^{-1}: up to m_H=130 GeV/c^2**
  - **$\int Ldt$ =8.0 fb^{-1}: up to m_H=135 GeV/c^2**

  } **Severely constrains MSSM**
- **3σ evidence: ★**
  - **$\int Ldt \approx$5.0 fb^{-1}: for m_H=115 GeV/c^2**

"God Does Not Play Dice" (with the Physicist)?

- **All numbers given so far were**
  - **a 50% probability of an experiment achieving discovery or exclusion**
  - **We perform 1 experiment**
- **Could get statistically lucky or unlucky (m_H=115 GeV/c^2):**
  - **with L=1 fb^{-1}:**
    - **5% chance for 3σ evidence**
    - **0% chance for 5σ discovery**
  - **with L=4 fb^{-1}:**
    - **35% chance for 3σ evidence**
    - **2% chance for 5σ discovery**
  - **with L=8 fb^{-1}:**
    - **75% chance for 3σ evidence**
    - **10% chance for 5σ discovery**

m_H=115 GeV/c^2

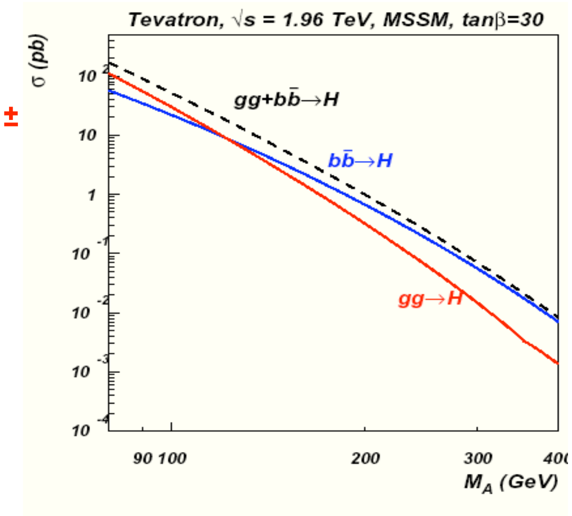


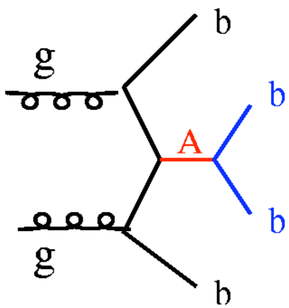
SUPERSYMMETRY

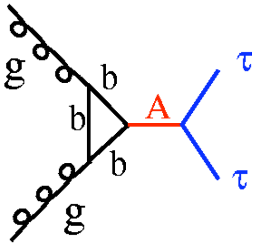
- **Addresses many questions and problems in SM:**
  - Elegant solution to hierarchy problem ($m_W << m_{Pl}$)
  - Achieves unification of gauge theories at GUT scale
  - Predicts a natural candidate for cold dark matter
    - if R–parity is conserved
- **More than 100 parameters:**
  - Rich phenomenology => many different signatures
- **Experimental status:**
  - No evidence found:
    - Stringent direct limits on sleptons and gauginos set by LEP: e.g. $m(\chi^{\pm}) > 103.5$ GeV/c^2
  - Consistent with measurements of $\Omega_{DM}h^2$, $(g\text{-}2)_\mu$, $b \rightarrow s\gamma$ and electroweak precision data

HIGGS: A→BB AND A→ττ

- **Supersymmetry (MSSM):**
  - 2 Higgs doublets => 5 Higgs bosons: h, H, A, $H^{\pm}$
- **High tanβ:**
  - A degenerate in mass with h or H
  - Cross sections enhanced with $\tan^2\beta$ due to enhanced coupling to down-type quarks
  - Decay into either ττ or bb:
    - BR(A →ττ) ≈ 10%, BR(A→ bb) ≈ 90%
    - Exact values depend on SUSY parameter space
- **Experimentally:**
  - pp → Ab+X → bbb+X
  - pp → A+X → ττ +X



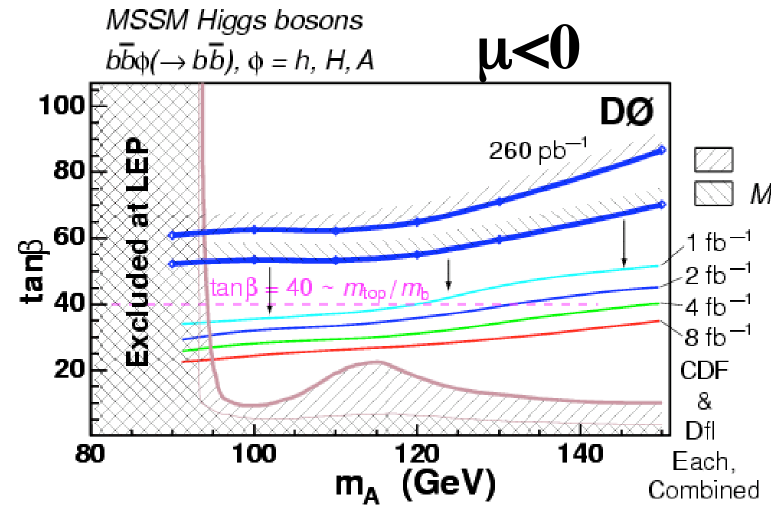


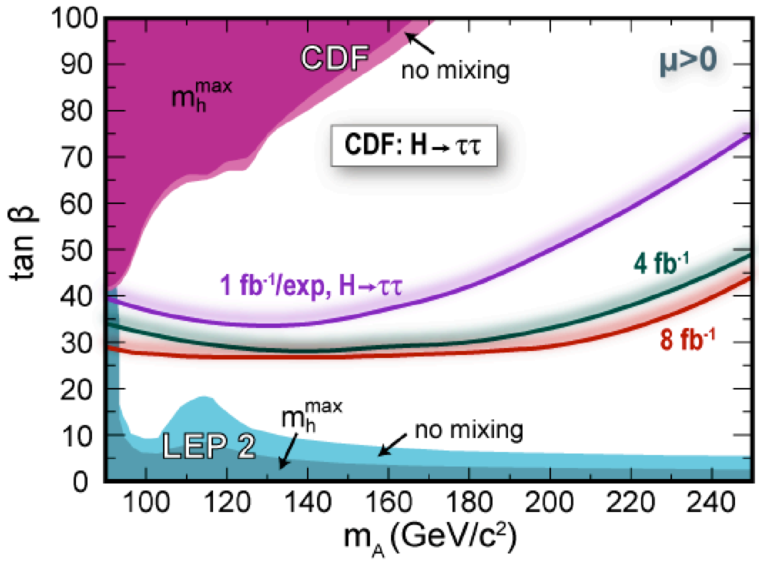


•C. Balazs, J.L.Diaz-Cruz, H.J.He, T.Tait and C.P. Yuan, PRD 59, 055016 (1999)
•M.Carena, S.Mrenna and C.Wagner, PRD 60, 075010 (1999)
•M.Carena, S.Mrenna and C.Wagner, PRD 62, 055008 (2000)

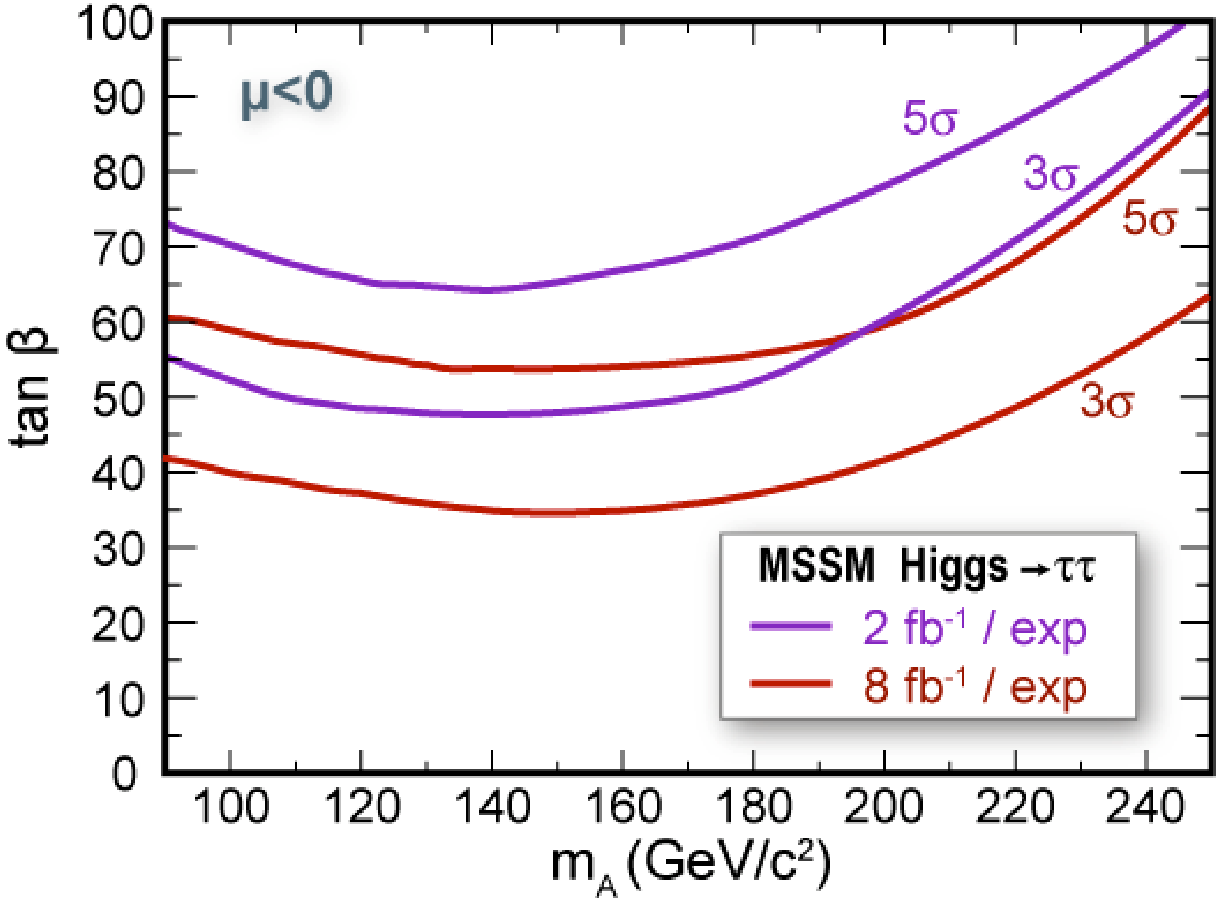
MSSM Higgs: Present and Future

- **First results in Run 2:**
  - **Probe tanβ>50–60 at low m_A**
  - **Channels complementary: different sensitivity to radiative corrections**
- **Will close gap to LEP with increasing datasets**
- **For tanβ=40≈m_{top}/m_b :**
  - **L=1fb^{-1}: m_A<170 GeV/c² @95%CL**
  - **L=4 fb^{-1}: m_A<225 GeV/c² @95%CL**
  - **L=8 fb^{-1}: m_A<240 GeV/c² @95%CL**
- **Simultaneous analysis of both decay channels will be crucial to know what it is**





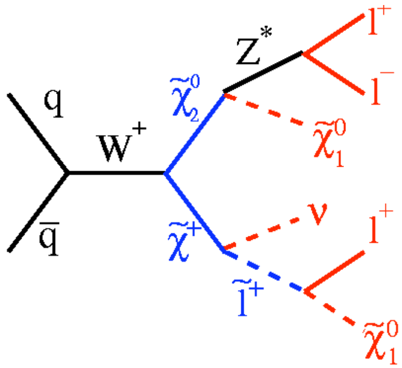
MSSM Higgs: Evidence/Discovery?

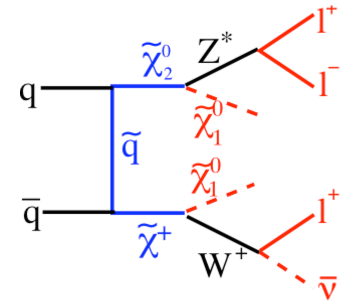


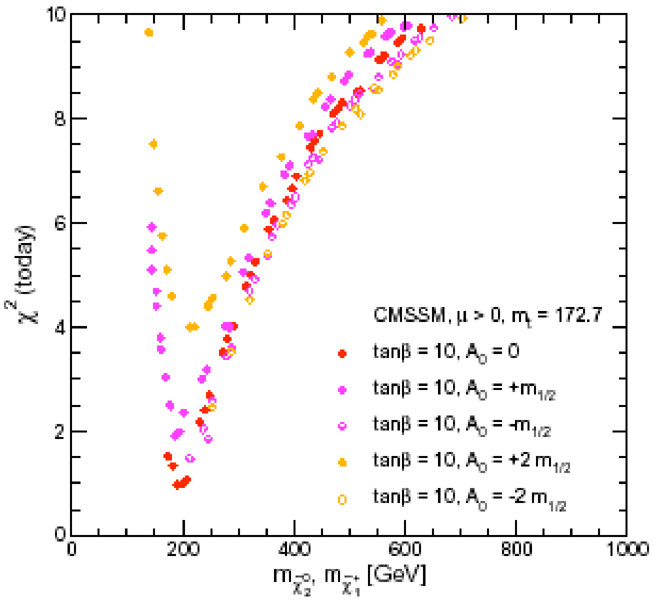
- **Discovery potential**
  - **L=2 fb^{-1} vs L=8 fb^{-1}:**
    - **improves reach by ~10 units in tanβ**

SUSY Trileptons

- "Golden" Trilepton Signature
  - Chargino–neutralino production
  - Low SM backgrounds
- 3 leptons and large Missing E_T:
  - Neutralino $\chi^0{}_1$ is LSP
- Recent analysis of electroweak precision and WMAP data (J. Ellis, S. Heinemeyer, K. Olive, G. Weiglein: hep-ph/0411216)
  - Preference for "light SUSY"
  - Chargino mass around 200 GeV/c²
- Current DØ analysis:
  - 2 l (l=e,μ,τ) + isolated track or $\mu^\pm\mu^\pm$
  - $\cancel{E}_t$ +topological cuts
  - Analysis most sensitive at low tanβ
  - BG expectation: 2.9±0.8 events
  - Observed: 3 events



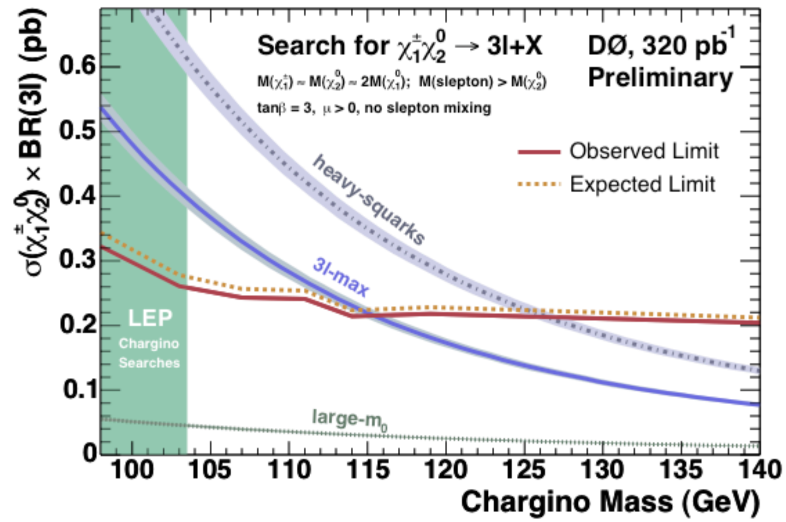


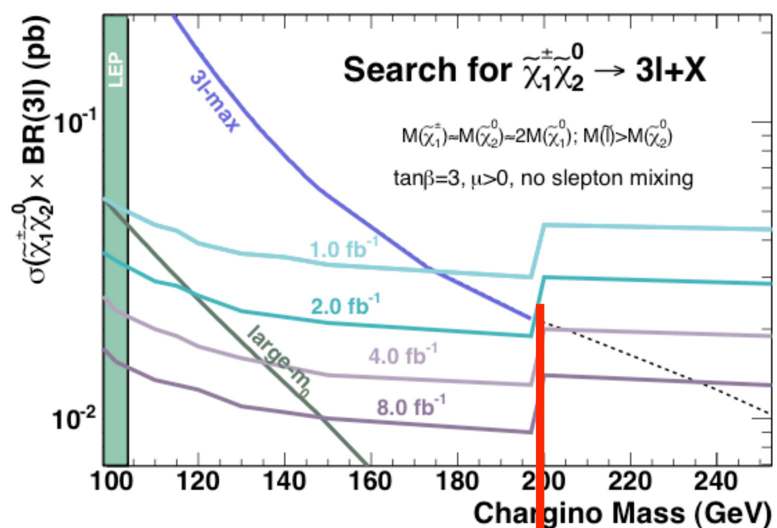


M(chargino)

Trileptons: Present and Future

- **Now**: **σxBR<0.2–0.3 pb**
  - **3l-max scenario**:
    - **Sleptons light**
    - **Optimistic mSUGRA**
  - **Large m_0 scenario:**
    - **Sleptons heavy**
    - **Pessimistic mSUGRA**
  - **Current data probe optimistic scenario**
- **Future:**
  - **Cross section limit 0.05–0.01 pb**
  - **L=1 fb^{-1}: probe chargino masses up to 100–170 GeV/c^2**
  - **L=8 fb^{-1}: probe chargino masses up to 150–240 GeV/c^2**

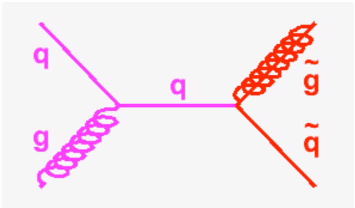


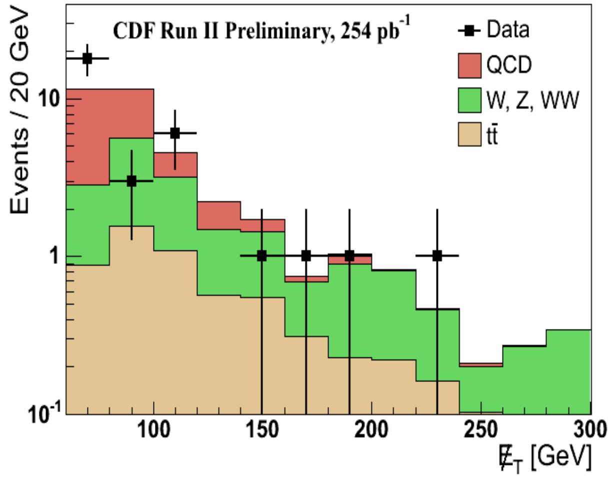


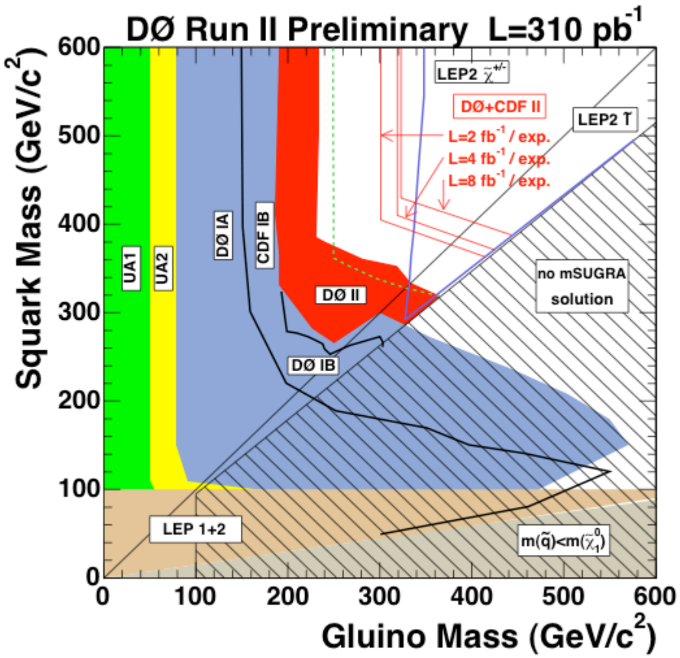
Preferred by precision data

Squarks and Gluinos

- Search for Missing Et+jets:
  - Strong production => Large production cross sections
  - Data consistent with SM background
  - Currently excluding masses up to 350 GeV for squarks and gluinos
- Future:
  - L=2 fb^{-1}: reach up to 400 GeV
  - L=8 fb^{-1}: reach up to 450 GeV
  - Could improve with further reoptimisation of cuts
- Not sensitive to stop quarks
  - ....and they are special

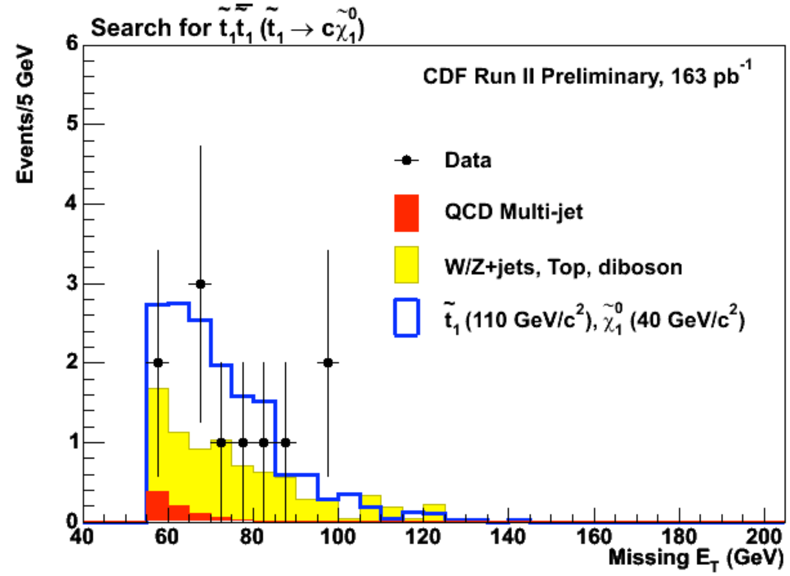


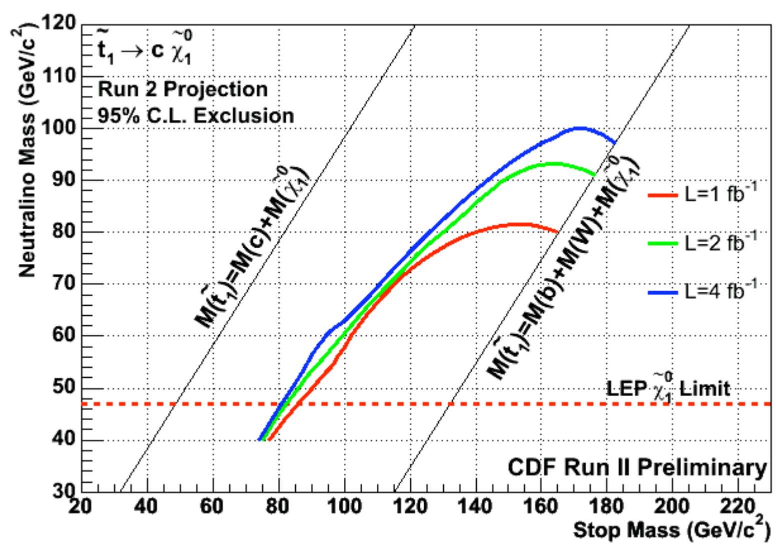




A Light Stop Quark?

- Stop mass “low” due to large mass and large Yukawa coupling of top quark
- Baryogenesis prefers light stop quark and Higgs boson
  - $m(\tilde{t})<165$ GeV/c²
- Several decay channels:
  - $\tilde{t} \rightarrow \tilde{\chi}^0 c$
  - $\tilde{t} \rightarrow l\tilde{\nu}b$
  - $\tilde{t} \rightarrow \tilde{\chi}^{\pm} b \rightarrow l\nu b$ or $t \rightarrow \tilde{\chi}^0 t \rightarrow \tilde{\chi}^0 l\nu b$
  - Depends on masses of $\tilde{\chi}^0, \tilde{\chi}^{\pm}, \tilde{t}, \tilde{\nu}$
- Light stop reach :
  - $L=1\ fb^{-1}$: $m(\tilde{t})<160$ GeV/c²
  - $L=4\ fb^{-1}$: $m(\tilde{t})<180$ GeV/c²



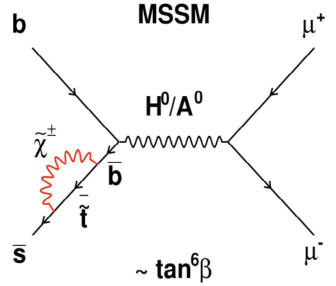


Rare Decay: $B_s \to \mu^+\mu^-$

- **SM rate heavily suppressed:**

  $$BR(B_s \to \mu^+\mu^-) = (3.5 \pm 0.9) \times 10^{-9}$$

  (Buchalla & Buras, Misiak & Urban)

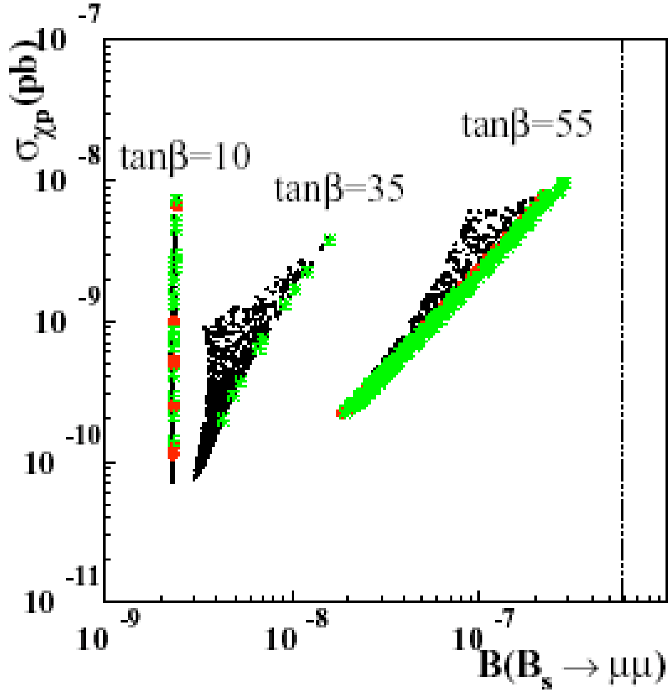


- **SUSY rate may be enhanced:**

  $$B(B_s \to \mu^+\mu^-) \propto \tan^6\beta / m_A^4$$

  (Babu, Kolda: hep-ph/9909476+ many more)

S. Baek, Y.G.Kim, P. Ko, hep-ph/0406033



- **Related to Dark Matter cross section (in one of 3 cosmologically interesting regions)**

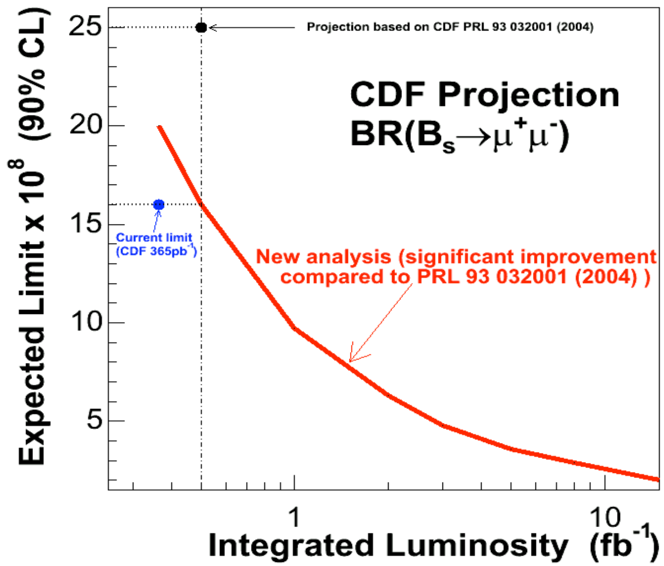
  $$\sigma_{\chi p} \propto \tan^2\beta / m_A^4$$

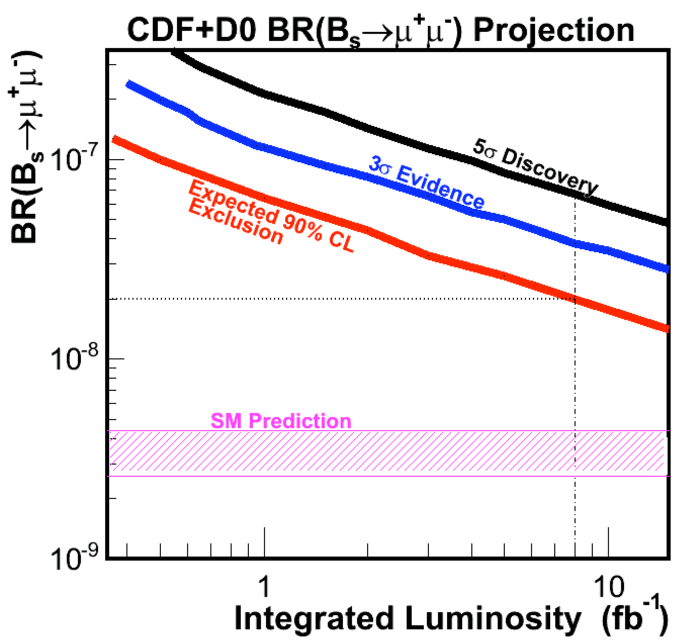
- **Recently gained a lot of attention when interpreting WMAP data**

Rare Decay: $B_s \to \mu^+\mu^-$

- **Current limits at 90% C.L.:**
  - **Fierce Competition:**
    1. CDF (L=171 pb^{-1}): BR < 5.8×10^{-7}
    2. DØ (L=240 pb^{-1}): BR < 4.1×10^{-7}
    3. DØ (L=300 pb^{-1}): BR < 3.0×10^{-7}
    4. CDF (L=364 pb^{-1}): BR < 1.6×10^{-7}
  - **Friendly combination:**
    1. CDF+DØ: BR < 1.2×10^{-7}
- **Projected reach (CDF+DØ):**
  - **Exclusion at 90% C.L.:**
    - L=1 fb^{-1}: BR < 6.4×10^{-8}
    - L=4 fb^{-1}: BR < 2.8×10^{-8}
    - L=8 fb^{-1}: BR < 2.0×10^{-8}
  - **Discovery at 5σ:**
    - L=1 fb^{-1}: BR = 2.1×10^{-7}
    - L=4 fb^{-1}: BR = 9.9×10^{-8}
    - L=8 fb^{-1}: BR = 6.7×10^{-8}

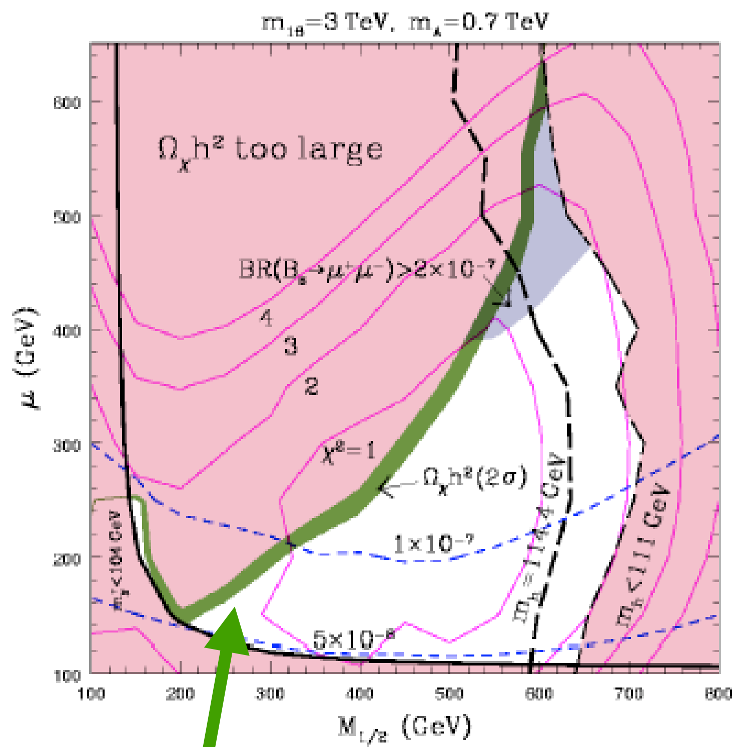
(this assumes no improvements to analyses)





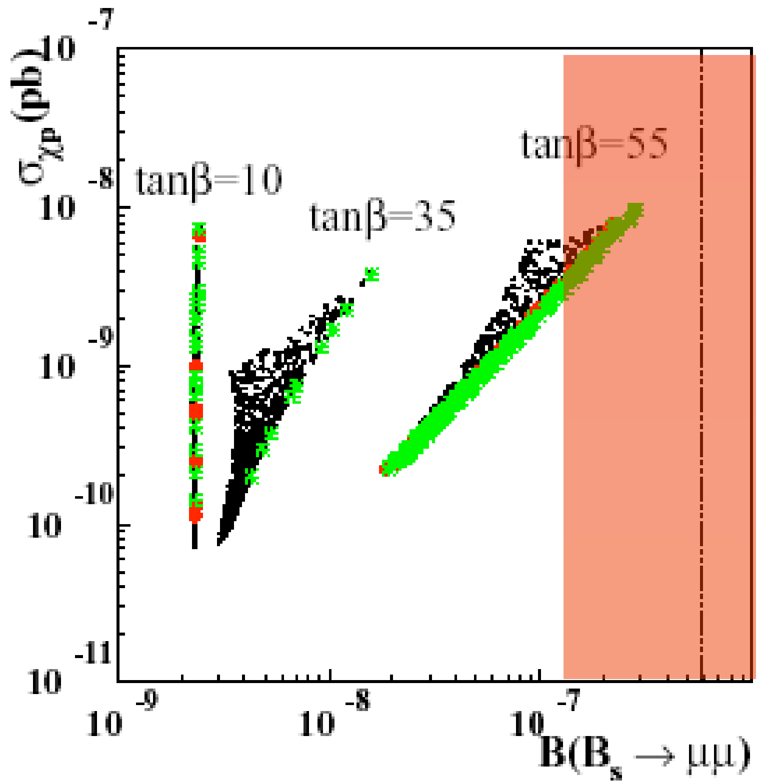
IMPACT OF $B_s \rightarrow \mu^+\mu^-$ LIMITS: NOW

R. Dermisek, S. Raby, L. Roszkowski,
R. Ruiz de Austri, hep-ph/0507233



Consistent with WMAP data

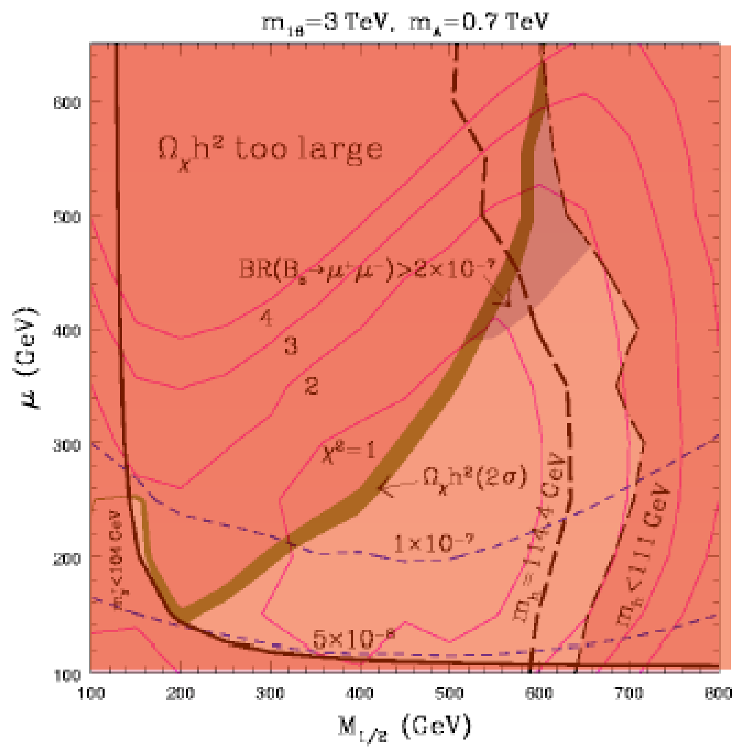
S. Baek, Y.G.Kim, P. Ko, hep-ph/0406033



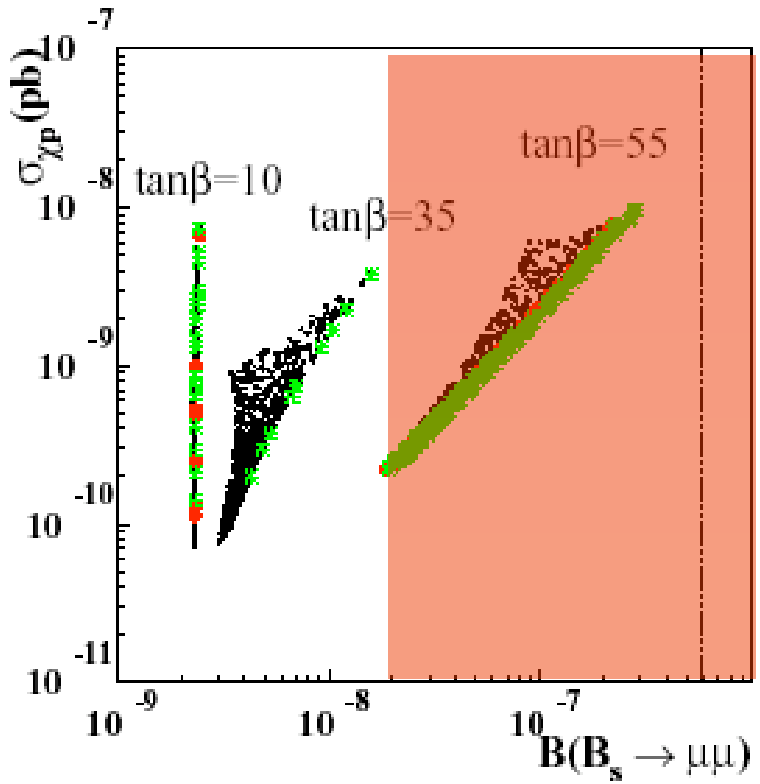
- **Starting to constrain MSSM parameter space**

IMPACT OF $B_s \rightarrow \mu^+\mu^-$ LIMITS: L=8 FB^{-1}

R. Dermisek, S. Raby, L. Roszkowski, R. Ruiz de Austri, hep-ph/0507233



S. Baek, Y.G.Kim, P. Ko, hep-ph/0406033



- **Will severely constrain parameter space**
  - **"Tevatron can rule out 29% of parameter space allowed by WMAP data within mSUGRA." B. Allanach, C. Lester, hep-ph/0507283**

1 vs 4 vs 8 fb^{-1}
What difference does it make?

	$\int Ldt = 1\ fb^{-1}$	$\int Ldt = 4\ fb^{-1}$	$\int Ldt = 8\ fb^{-1}$
SM Higgs: 95% C.L. excl.	m_H <100 GeV/c^2	m_H <130 GeV/c^2	m_H <135 GeV/c^2
m_H=115 GeV/c^2: 3σ evidence	5% chance	35% chance	75% chance
m_H=115 GeV/c^2: 5σ discovery	0% chance	2% chance	10% chance
MSSM A, tanβ=40: 95%CL excl	m_A<170 GeV	m_A<225 GeV	m_A<240 GeV
MSSM A @140 GeV: 5σ disc.	tanβ=70	tanβ=60	tanβ=55
3leptons (3l-max): 95%CL excl	m($\chi^\pm$) < 170 GeV	m($\chi^\pm$) < 200 GeV	m($\chi^\pm$) < 230 GeV
3leptons (large m0): 95%CL excl.	m($\chi^\pm$) <100 GeV	m($\chi^\pm$) < 135 GeV	m($\chi^\pm$) < 150 GeV
Gluinos: 95% C.L. excl.	–	M<420 GeV	M<450 GeV
Stop quarks: 95% C.L. excl.	M($\tilde{t}$)<160 GeV	M($\tilde{t}$)<180 GeV	M($\tilde{t}$)<185 GeV
$B_s \to \mu\mu$: 95% C.L. excl.	BR<6.4 x 10^{-8}	BR<2.8 x 10^{-8}	BR<2.0 x 10^{-8}
$B_s \to \mu\mu$: 5σ discovery	BR=21.0x 10^{-8}	BR=9.9 x 10^{-8}	BR=6.7 x 10^{-8}
Z' discovery, e.g. E6 model	M=720 GeV	M=820 GeV	M=870 GeV
LED: 95% C.L. excl.	M<1.8 TeV	M<2.15 TeV	M<2.35 TeV

However …
We Are Experimentalists!

And So Much More!!! (e.g. CDF)

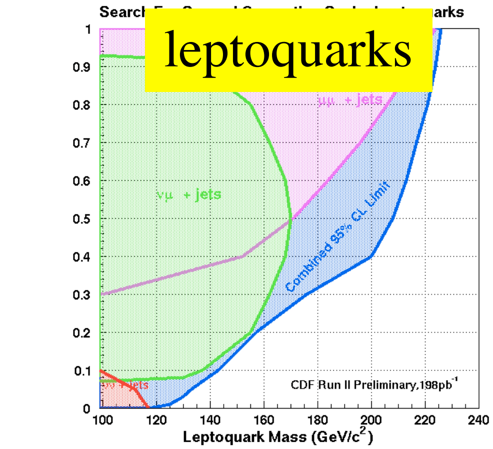
- Published/Submitted:
  - H^{++}->ee,$\mu\mu$,eμ
  - H^{++}, stable double charged particle
  - Excited electrons
  - GMSB: $\gamma\gamma$+ME_T
  - LQ->ννqq
  - Magnetic monopoles
  - MSSM Higgs: A->$\tau\tau$
  - LQ, 1st gen.
  - Z'->ee, $\mu\mu$, $\tau\tau$
  - B_s->$\mu\mu$
- Other (no result yet):
  - Photon+ME_T (LED+GMSB)
  - Like-sign dileptons
  - Dileptons at large q_T
  - 4-leptons
  - B_s ->$\mu\mu\phi$
  - Excited muons and taus
  - tt+Higgs
  - GMSB Stop: $\gamma\gamma$+2jet+MEt
  - Lepton-flavor violating Higgs
  - MSSM Higgs: A+b ->bb+b
  - Excited quarks
  - Dijet mass resonance
  - Syst. Scan of high p_T data
- Preliminary results:
  - 4th generation quarks: b', t'
  - Diphoton resonance
  - W'->eν
  - SM Higgs
  - Charged Higgs
  - Vector LQ, 3rd gen.
  - LQ, 2nd gen.
  - Gluino->sbottom+bottom
  - Squark/gluino->jets+ME_T
  - Stop: 2 decay modes
  - RPV stop quark
  - RPV sneutrino
  - Trileptons
  - monojets
  - lepton+gamma+X
  - Ditop resonance
  - High Et jets
  - CHAMPs: CHArged Massive Particles
  - Longlived particle decaying to Z+X

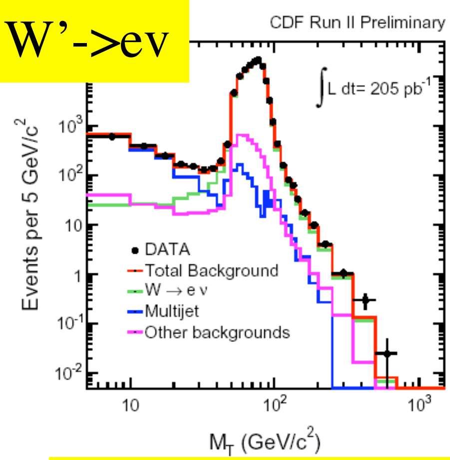
Blue: shown here

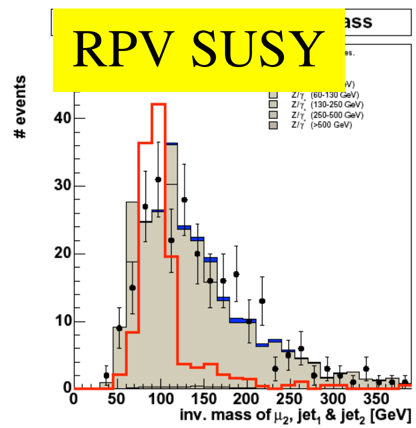
Black: not shown here

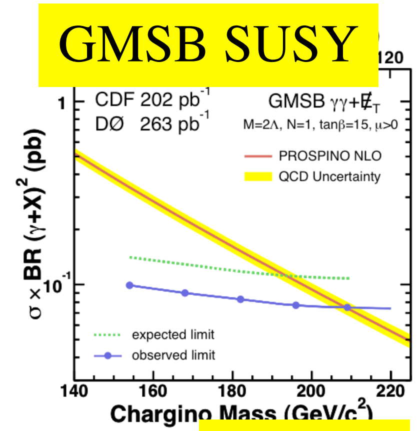
(similar at DØ)

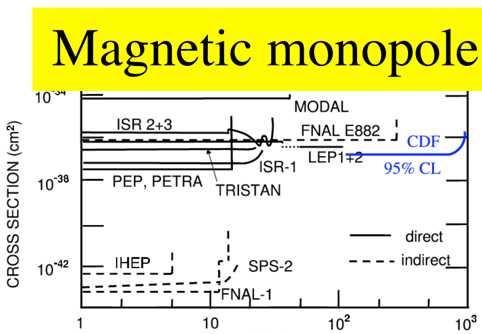
About 1/6 of Run 2 Search Results

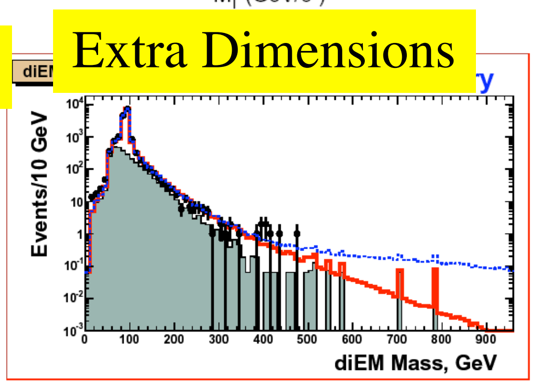


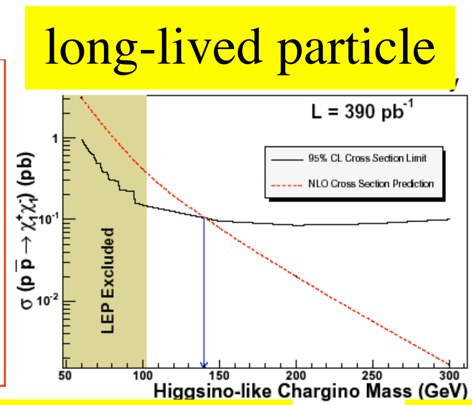


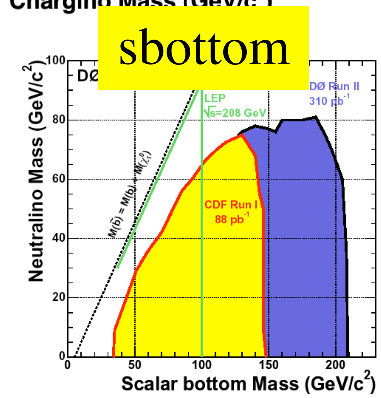


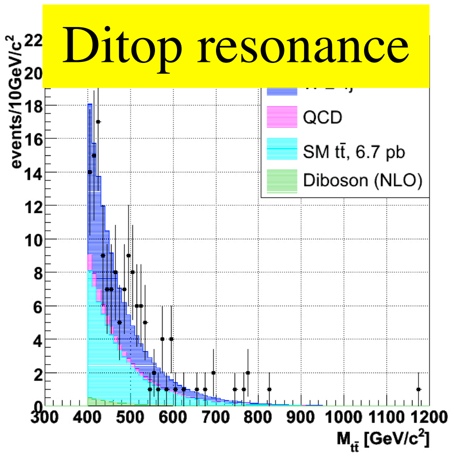


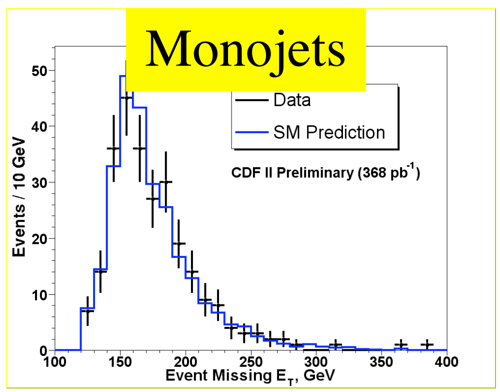


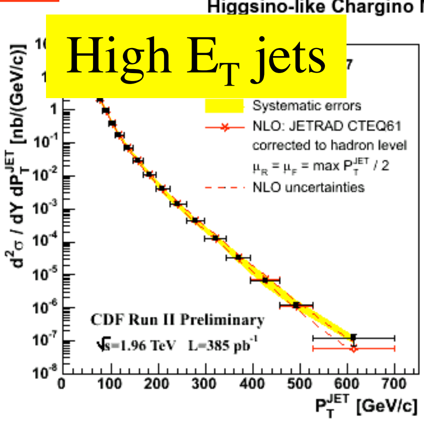


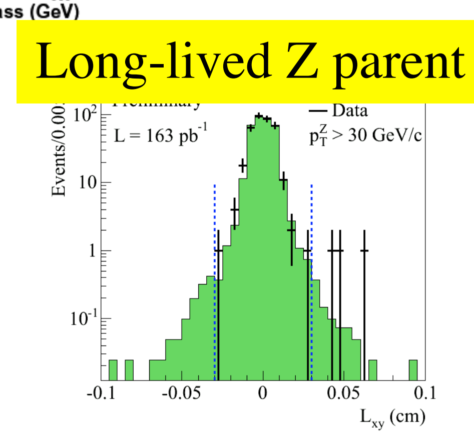










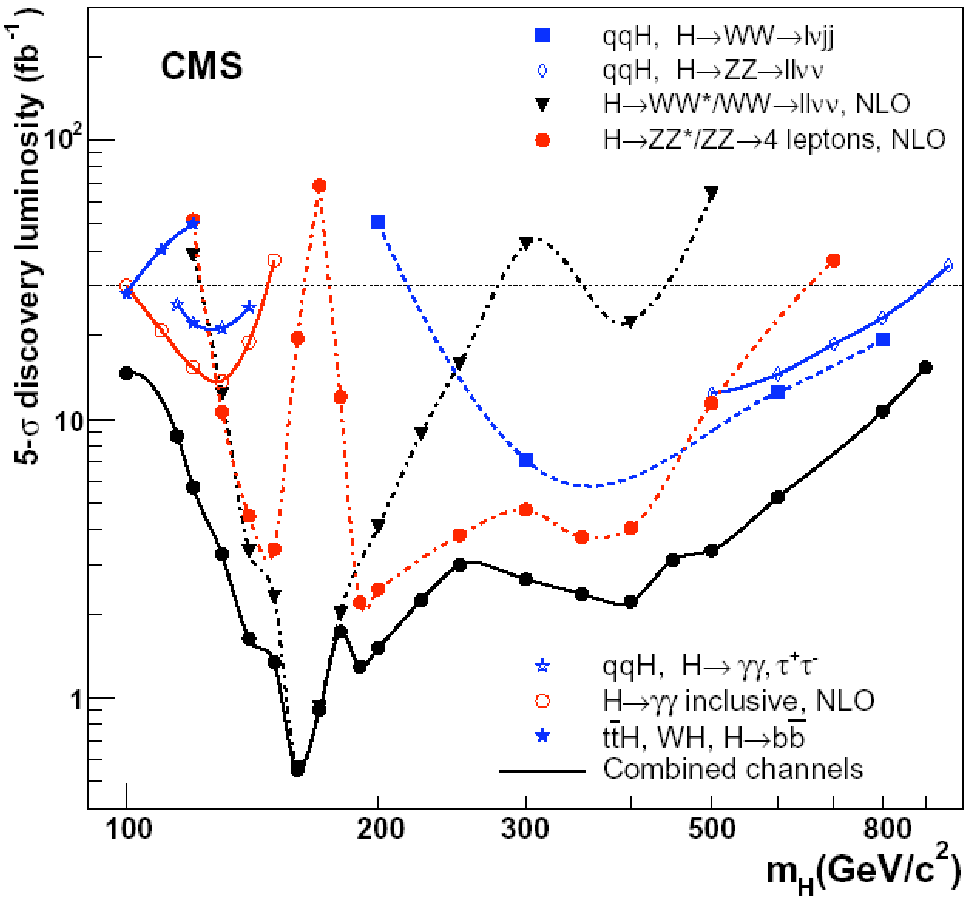


Conclusions

- Discovery potential:
  - Predictions based on Run 2 analysis experience
  - Standard Model Higgs
    - $L=2.5\ fb^{-1}$: Probe LEP excess at $m_H=115\ GeV/c^2$
    - $L=4–8\ fb^{-1}$: significant exclusion or evidence
      - Tevatron competitive with LHC until experiments complete analysis of $L \approx 5\ fb^{-1}$
  - SUSY
    - Discovery potential:
      - Higgs, Trileptons, squarks/gluinos, $B_s \to \mu^+\mu^-$
      - Tevatron less competitive with LHC experiments
        - » How exactly depends on model parameters and type
  - Many other models (Z', Extra Dimensions, etc.)
- We are explorers
  - Model independent searches for signatures
  - Don't know whether any theory is right!
- We may find the unexpected
  - Every 1–2 weeks a "blind box" is opened and an exciting surprise may show up!

BACKUP SLIDES

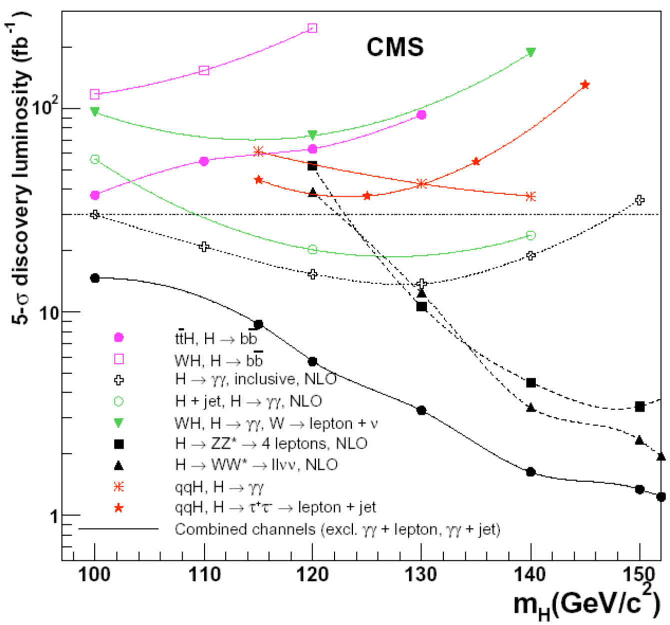
LHC Higgs Discovery Potential

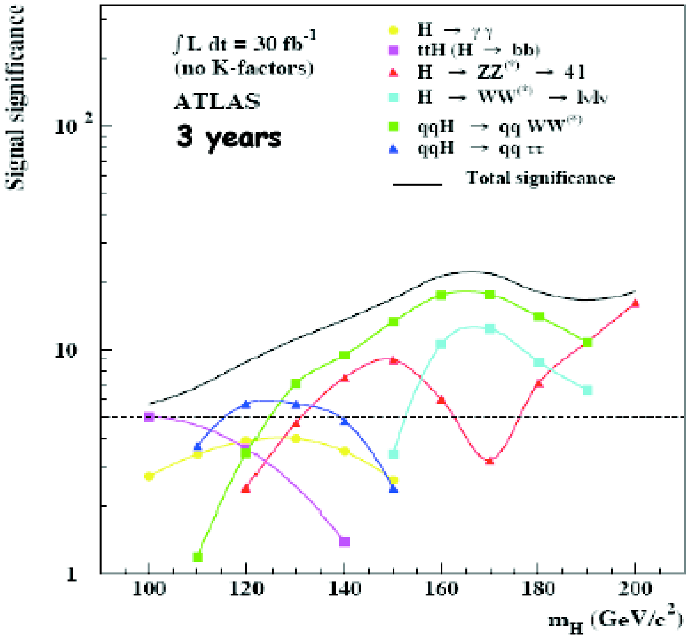


F. Gianotti, LP2005:
"the LHC experiments may collect several fb^{-1} by end of 2008."

- **Very fast for high mass, e.g. 160 GeV/c^2:**
  - **L=500 pb^{-1} in h→WW channel**
- **Harder at low mass => zoom into low mass region**

LHC: Low Mass Region

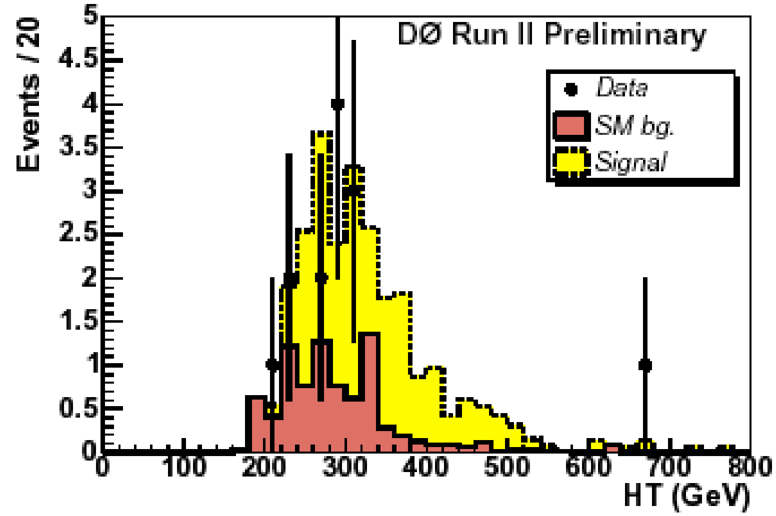


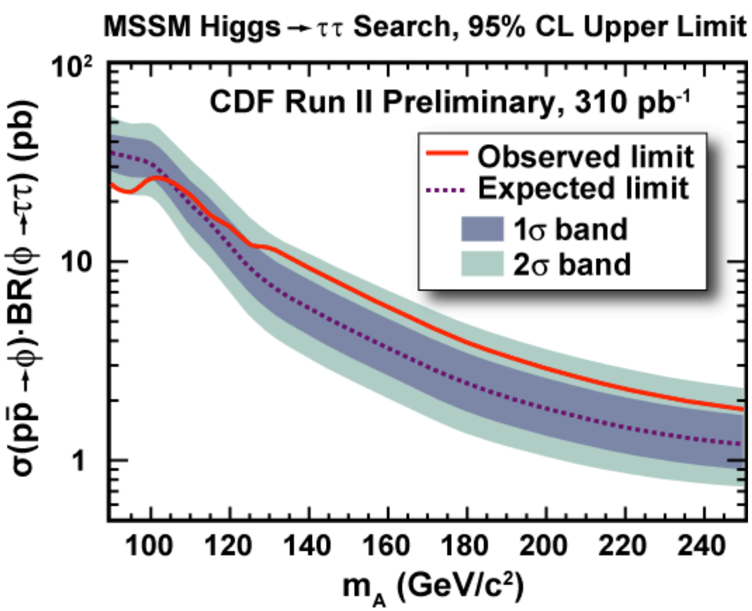


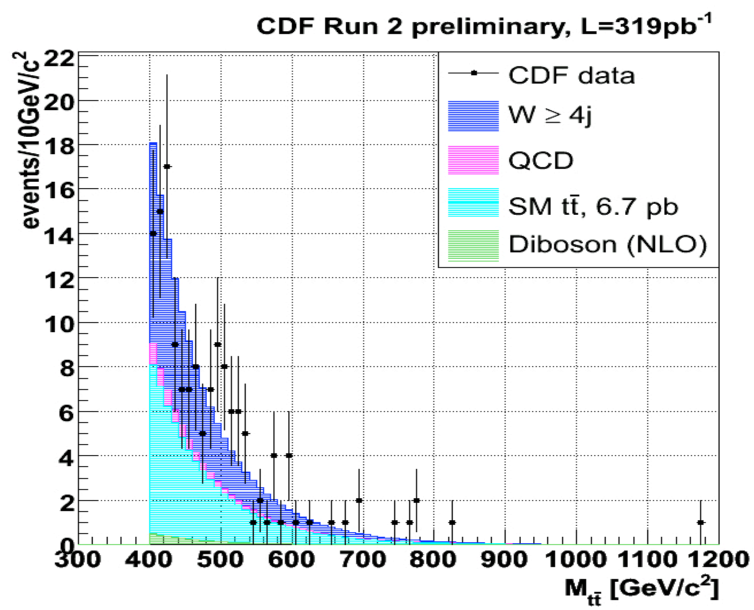
- m_H=115 GeV/c^2
  - Three channels contribute, each with about 2–3σ:
    - H->γγ, ttH->ttbb, qqH->qqττ
- Combining those three channels:
  - Require L≈10 fb^{-1} for 5σ discovery with single experiment at m_H=115 GeV/c^2
- Tevatron results competitive until at least 5 fb^{-1} have been analysed by both LHC experiments

Any Hints in the Current Data?

- **Not significant but, e.g.**
  - **Gluino candidate event at H_T=660 GeV**
  - **2σ excess in ditop mass spectrum at 500 GeV**
  - **1.5σ excess in Higgs ditau search**
- **Only more data can tell…**

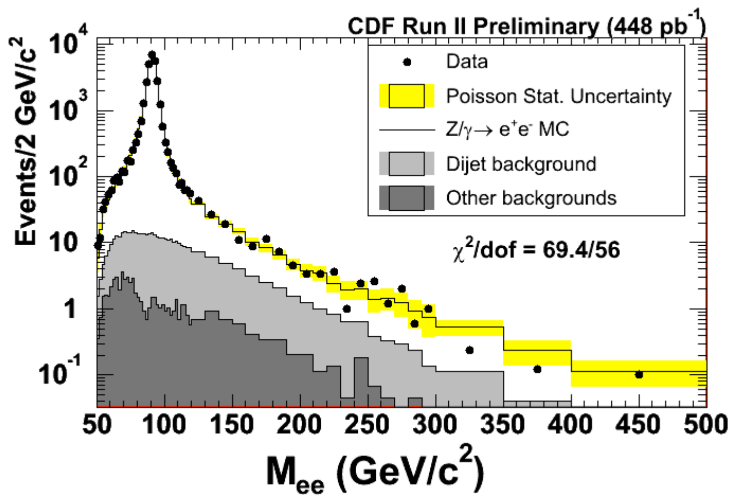






Z´ Discovery Reach

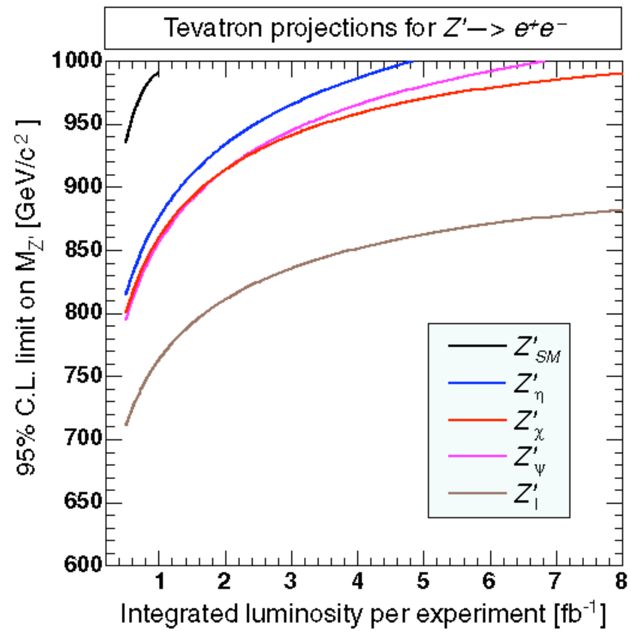
- $Z' \rightarrow e^+e^-$ with $m_{Z'}$=1 TeV/c^2 and SM couplings:
  - LHC (F. Gianotti, M. Mangano, hep-ph/0504221) :
    - 5σ discovery with $\int L dt$=70 pb^{-1}
  - Tevatron:
    - 95% CL exclusion with $\int L dt$=1 fb^{-1}
    - 3σ discovery with $\int L dt$=1.3 fb^{-1}
    - 5σ discovery with $\int L dt$=1.5 fb^{-1}



LHC projections (from M. Mangano)

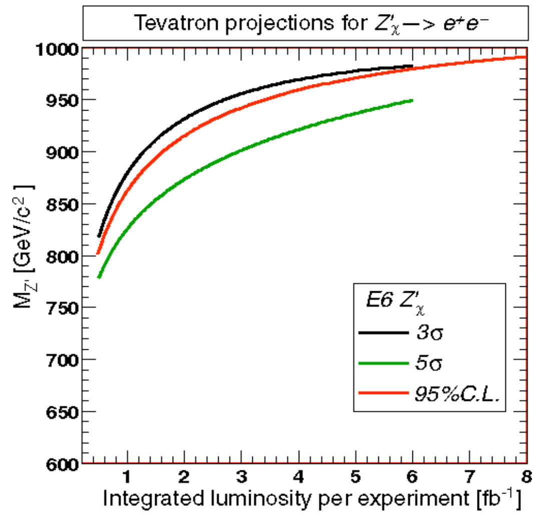
$Z' \rightarrow ee$, SSM

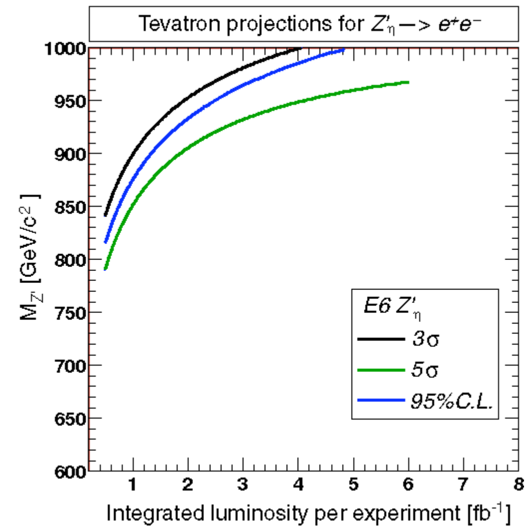
Mass	Expected events for 10 fb^{-1} (after all cuts)	$\int L\,dt$ needed for discovery (corresponds to 10 observed evts)
1 TeV	~ 1600	~ 70 pb^{-1}
1.5 TeV	~ 300	~ 300 pb^{-1}
2 TeV	~ 70	~ 1.5 fb^{-1}

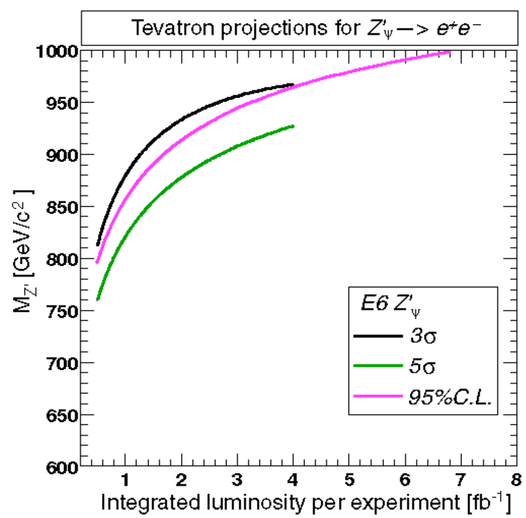


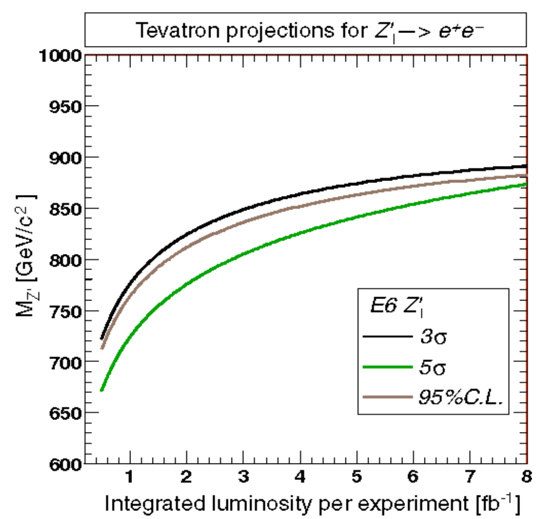
Z´ Discovery

- **Several models inspired by E6 theories**

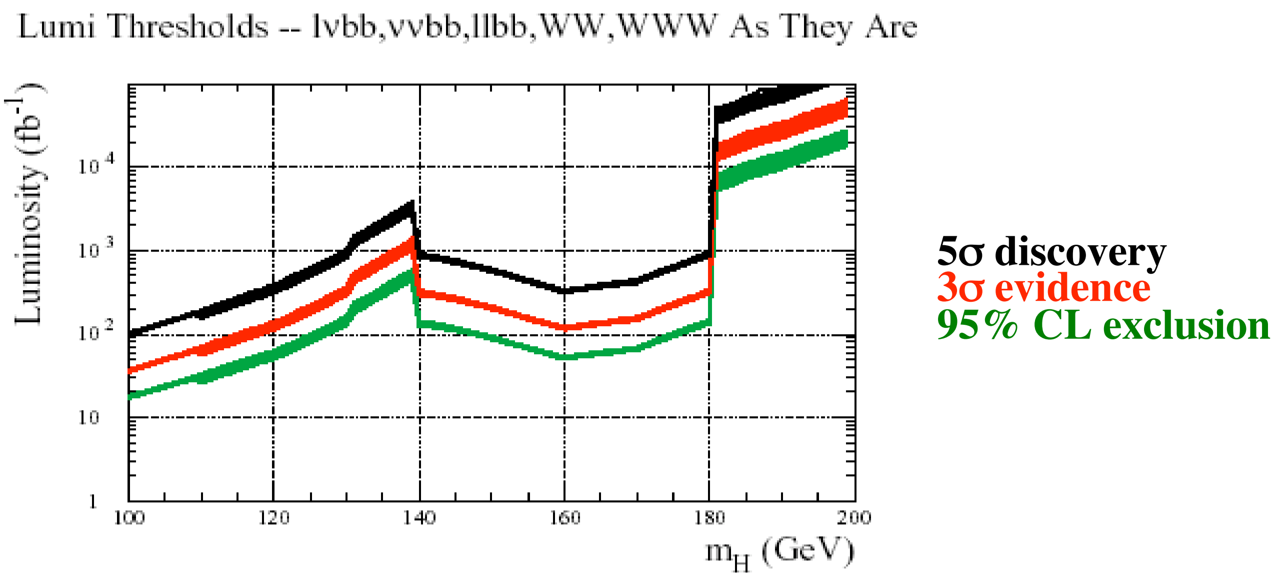








Higgs: Systematic Uncertainties



- **Width of bands shows difference between:**
  - **Assume current systematic uncertainties improve with 1/√L**
  - **No systematic uncertainties**
  - **Factor 1.4 difference in luminosity between those assumptions**
- **Main systematic uncertainties determined by data statistics, e.g.:**
  - **Wbb and Wc background normalisation (currently 40%)**
  - **mistags**

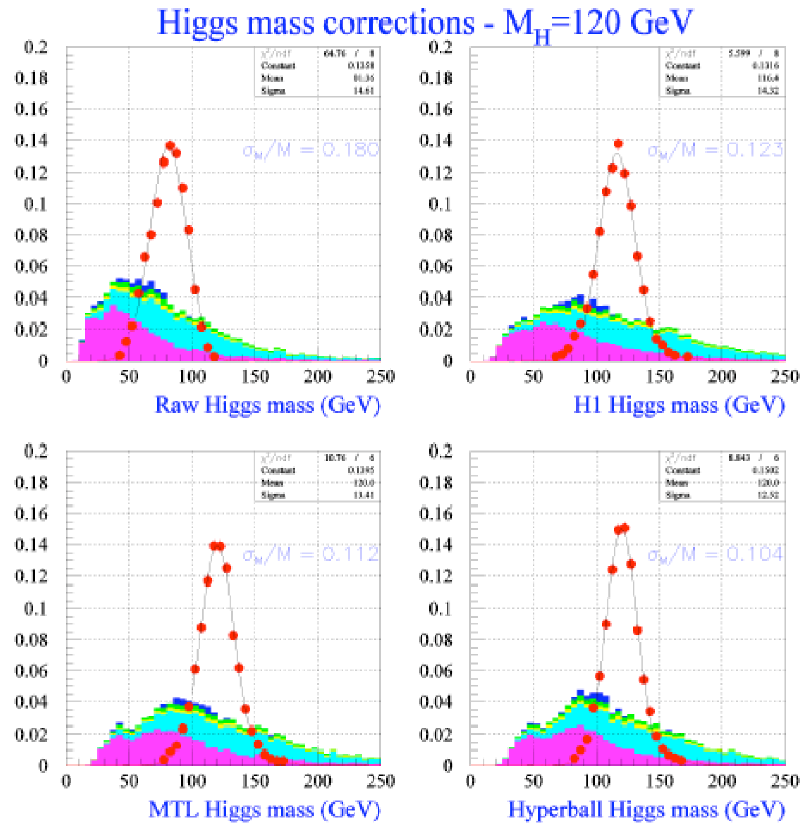
WH Signal in ZH→ννbb Analysis

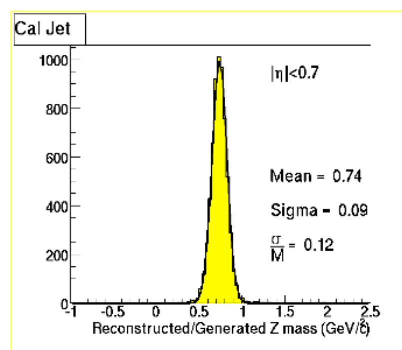
- This is easy!
  - Got factor 2.1 with current analysis (CDF):
    - S/√B increases: 0.062 => 0.091
    - Luminosity factor=$(S/\sqrt{B})^2$=2.1
    - DØ observe factor 1.6
- Remarks:
  - ZH→ννbb analysis:
    - vetoes against isolated tracks, electron and muons
  - Exact factor depends on veto cuts
    - Cross-talk with lepton and track-only selections
    - being further optimised with global view on all analyses
- Assume factor 2.7 with optimal lepton selection/vetoes

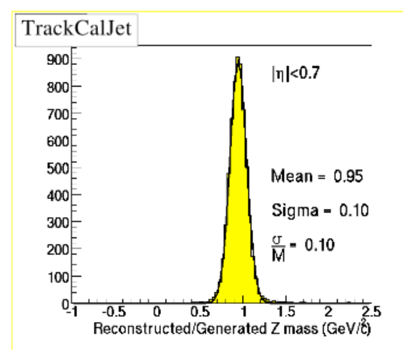
	CDF	DØ
ZH signal	0.13	0.065
WH signal	0.06	0.018
Background	4.4	2.2
S(ZH)/√B	0.062	0.043
S(ZH+WH)/√B	0.091	0.055

HIGGS: MASS RESOLUTION

- **Current value:**
  - **CDF 17%, DØ 14%**
- **HSWG result: 10.4%**
- **How do we get there?**
  - **Combine track and calorimeter information: 2%**
  - **Expand cone size (CDF): 2%**
  - **Specific corrections for b-jets: 1–2%**
  - **Fancy algorithms ("hyperball"): 1–2%**
- **1% in mass corresponds to 10% in luminosity**

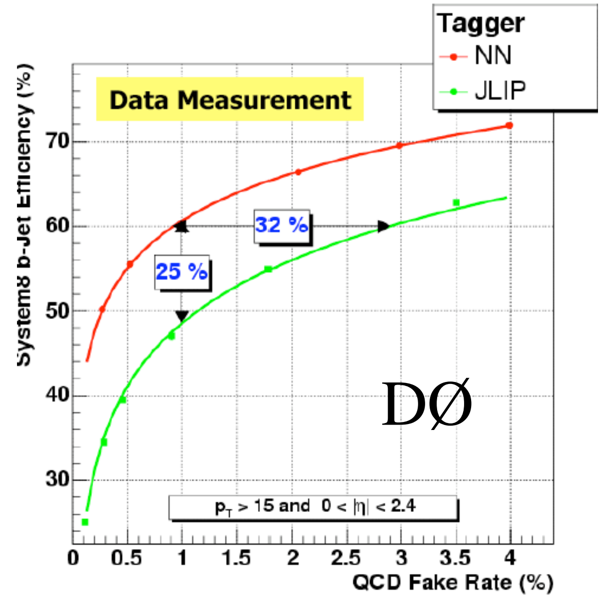


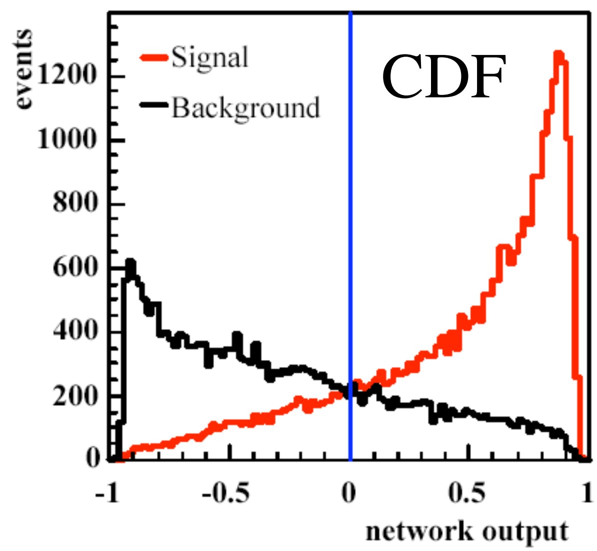




Higgs: NN B-tagging

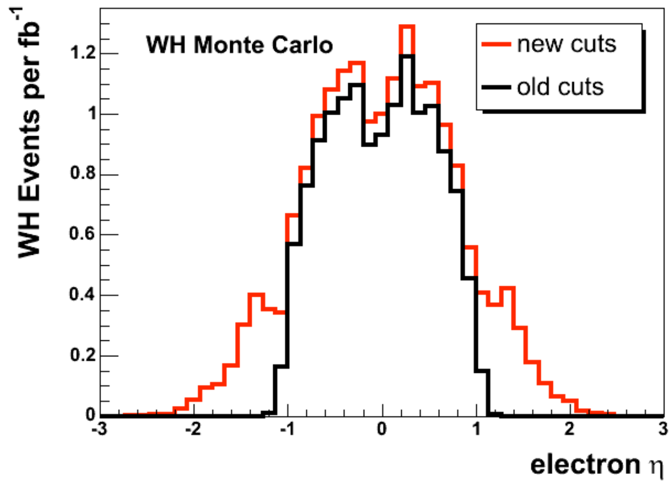
- Neural Net b-tagging
  - first versions available in both experiments
  - DØ achieve 25% improvement now by cutting on NN output
  - Exploit full distribution:
    - better statistical power
    - Best events count most
    - e.g. Factor 1.2
      - simply combining single and double tag samples
- Factor 1.5 is likely achievable

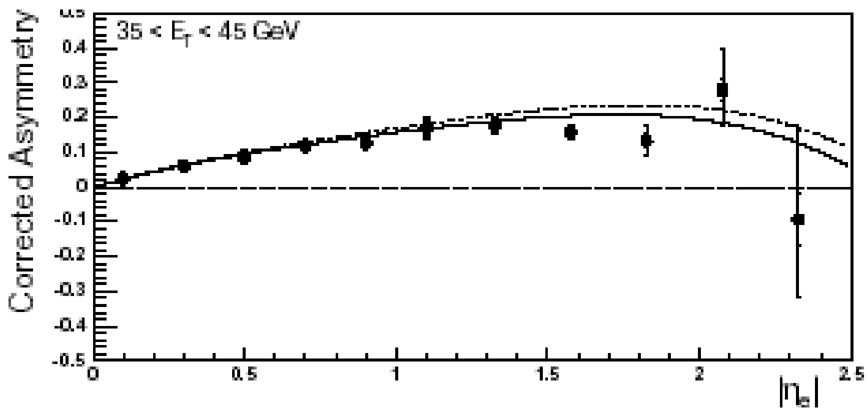




Higgs: Lepton Selection

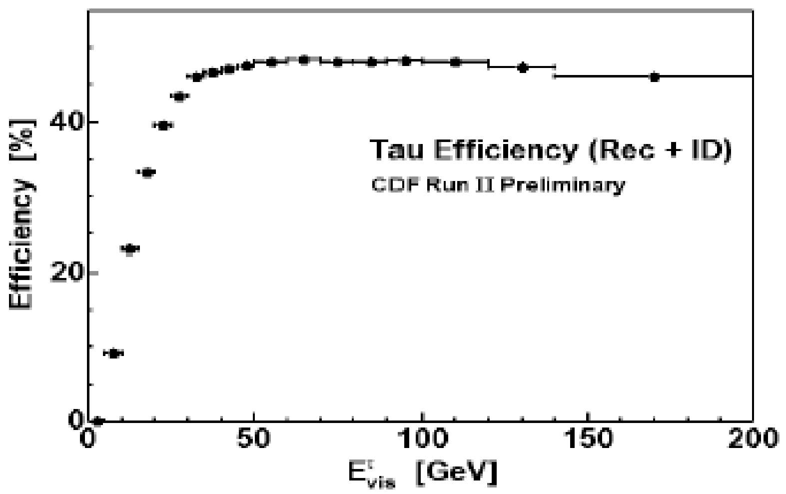
- **Forward leptons:**
  - Assume gain of factor 1.3
  - Current analyses use only up to $|\eta|<1.1$
- **Available improvements:**
  - CDF:
    - Forward electrons used already by other analyses, e.g. W charge asymmetry
    - Up to $|\eta|<2.8$
    - Central electrons and muons: recently improved efficiency by ~5%
    - Factor 1.34 in acceptance
  - D0:
    - Estimate 50% gain from trigger, lepton ID and using electrons near cracks

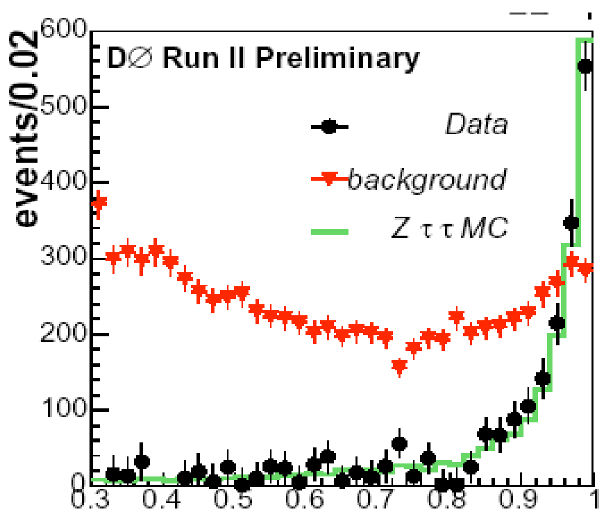




IMPROVEMENT 5: TRACK LEPTON

- **Track leptons: 1.4**
  - **Catch one-prong tau-decay**
  - **Catch region with poor muon/calorimeter instrumentation**
    - **Depends on how well we identify electrons and muons**
  - **CDF already uses them in top dilepton selection:**
    - **Signal: 17.2->21.7 events**
    - **25% signal increase**
- **Can also do full tau ID:**
  - **See later MSSM higgs search**
  - **Tau ID:**
    - **Cut based: ε≈45%**
    - **NN based: ε≈ 80%**
  - **Not yet evaluated potential**





Factor 1.4 reasonable

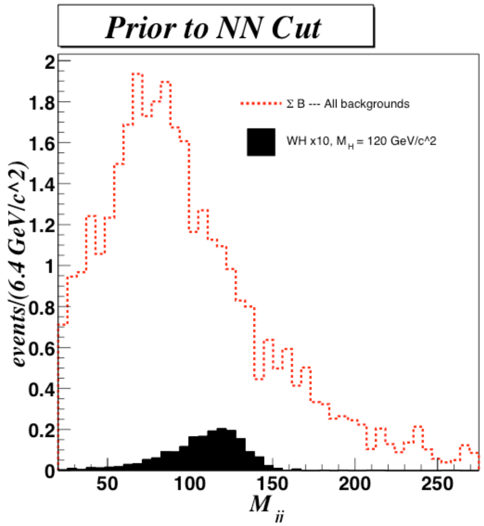
WH→eνbb in DØ

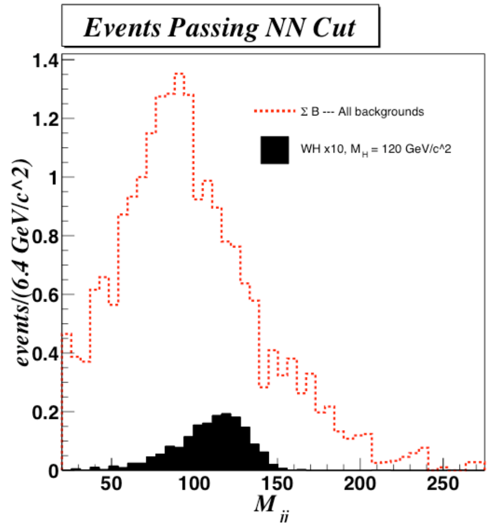
- **Improvements:**
  - Forward leptons: 26%
  - B–tagging: 40%
  - Trigger+ID: 30%
  - Mass resolution: 40%
- **Total:**
  - Factor 1.85 in S/√B
  - Luminosity equivalent: 3.4

	now	future(*)
Mass resolution	14%	10%
Signal	0.12	0.48
Background	2.37	5.79
S/√B	0.08	0.20

(*) 2003 HSWG study without NN assumption, scaled to L=382 pb^{-1}

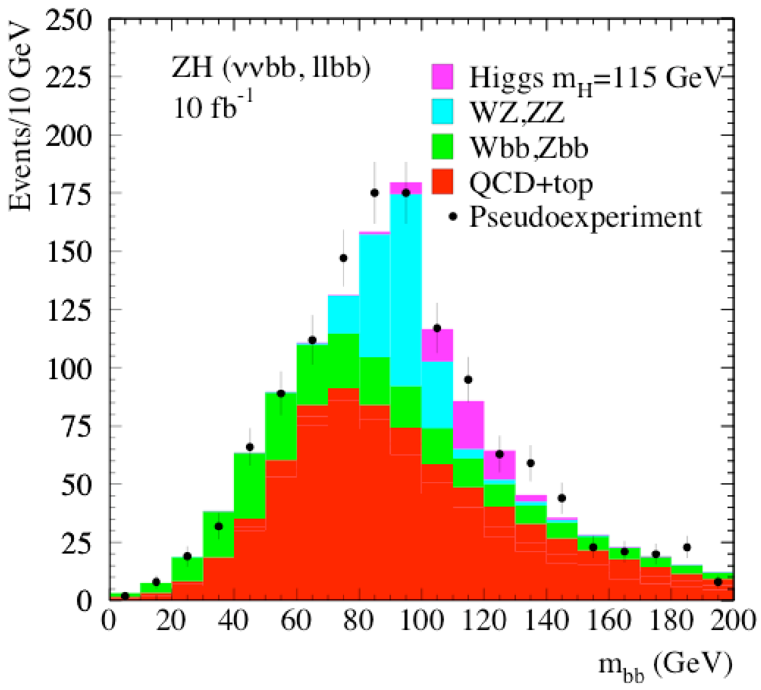
Does the NN Create a Mass Bias?

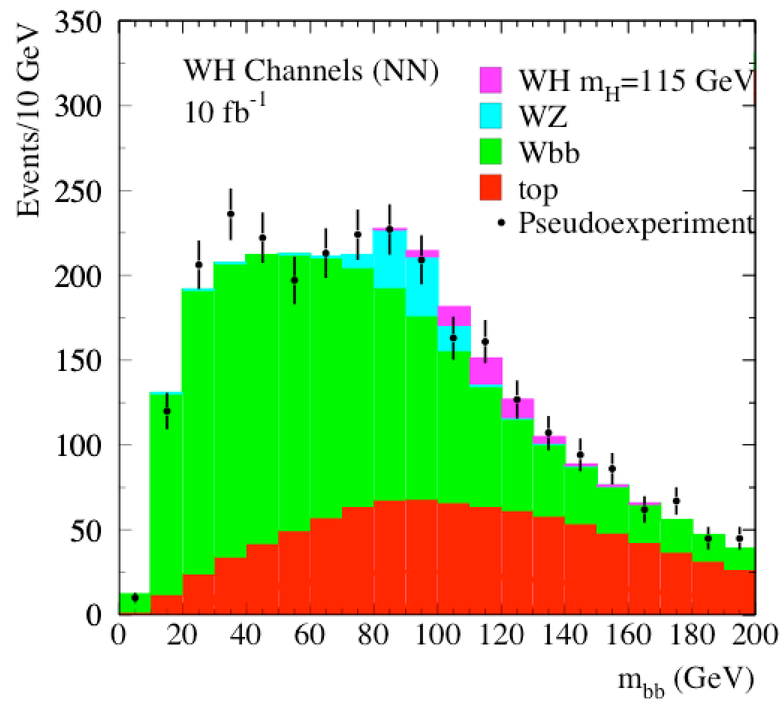




- **WH NN from Run I:**
  - **Avoids using variables correlated with mass**
  - **Expected limit improved from 13 pb to 10 pb => luminosity equivalent is $(13/10)^2=1.7$**
- **Background shape not biased towards higgs mass**
- **Better discrimination when mass used in NN (~2)**
  - **But will we believe the pure NN output?**
  - **Can test this with other channels, e.g. WW->jjlv**

How does the Higgs Signal look like?



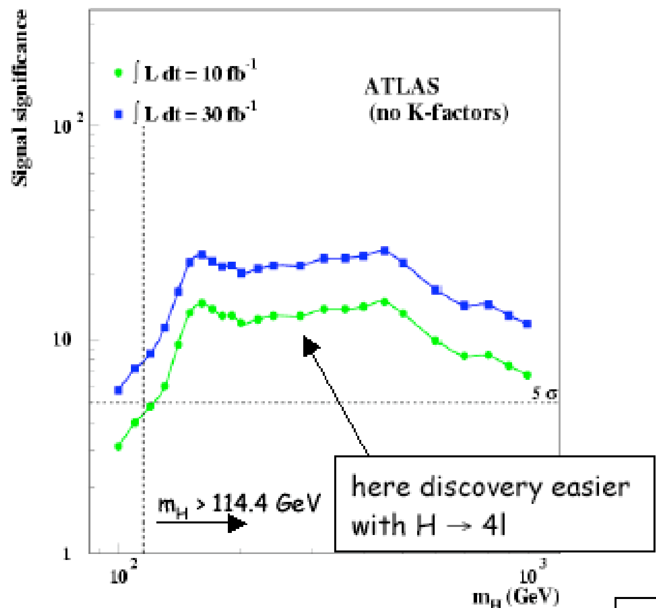


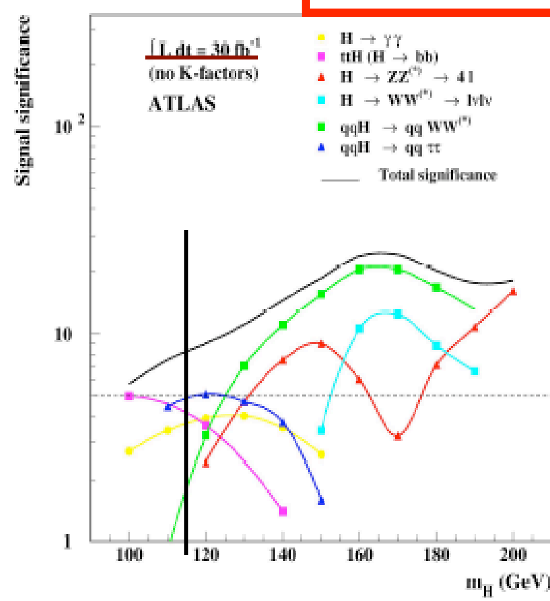
- **Will first observe WZ:**
  - **excellent calibration channel**
  - **tests validity of procedure**

LHC: Higgs at 115 GeV/c^2

A difficult case: a light Higgs ($m_H \sim 115$ GeV) ...

from F. Gianotti, LP 2005





$m_H \sim 115$ GeV	10 fb^{-1}

total $S/\sqrt{B} \approx 4^{+2.2}_{-1.3}$

ATLAS	$H \to \gamma\gamma$	$ttH \to ttbb$	$qqH \to qq\tau\tau$ (ll + l-had)
S B	130 4300	15 45	~ 10 ~ 10
$S/\sqrt{B}$	2.0	2.2	~ 2.7

K-factors $\equiv \sigma(NLO)/\sigma(LO) \approx 2$ not included

Full GEANT simulation, simple cut-based analyses

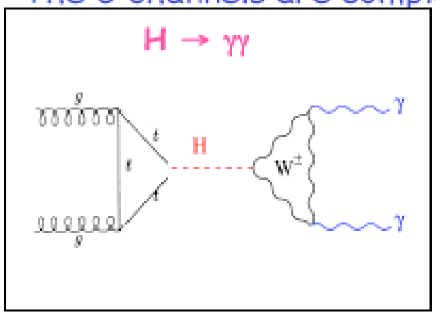
LHC: Higgs at 115 GeV/c^2

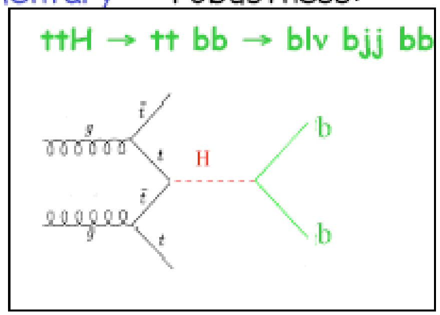
from F. Gianotti, LP 2005

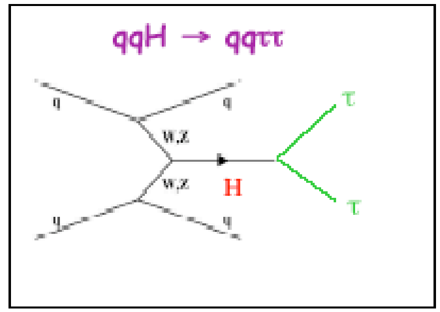
Remarks:

Each channel contributes ~ 2σ to total significance → observation of all channels important to extract convincing signal in first year(s)

The 3 channels are complementary → robustness:







- different production and decay modes
- different backgrounds
- different detector/performance requirements:
  - -- ECAL crucial for H → γγ (in particular response uniformity) : σ/m ~ 1% needed
  - -- b-tagging crucial for ttH : 4 b-tagged jets needed to reduce combinatorics
  - -- efficient jet reconstruction over $|\eta|$ < 5 crucial for qqH → qqττ : forward jet tag and central jet veto needed against background

Note : -- all require "low" trigger thresholds

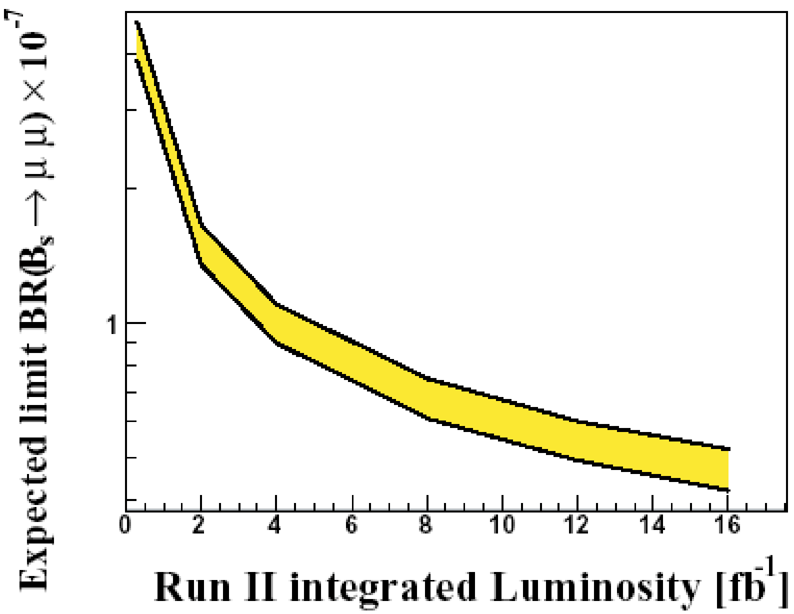
E.g. ttH analysis cuts : p_T (l) > 20 GeV, p_T (jets) > 15-30 GeV

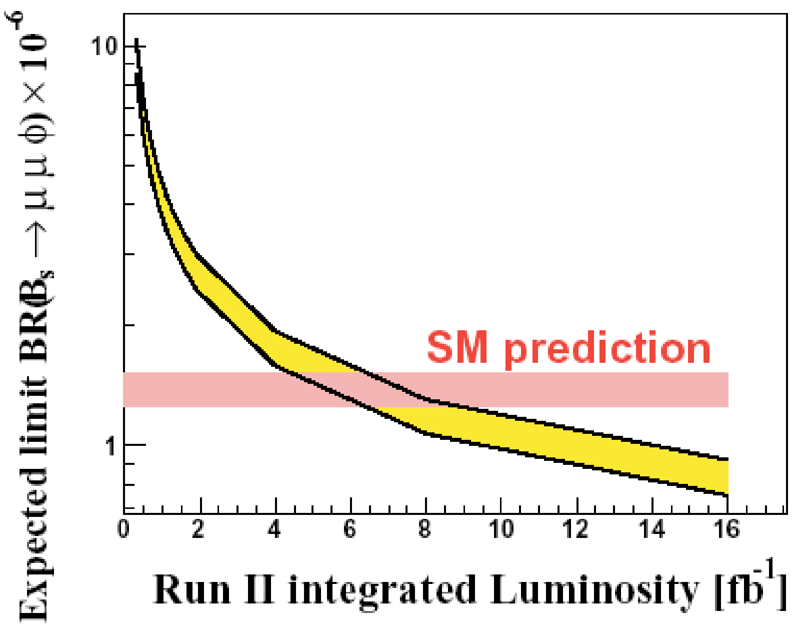
-- all require very good understanding (1-10%) of backgrounds

D0: Rare Decays

$B_s \rightarrow \mu\mu$ and $B_s \rightarrow \mu\mu\phi$

- Based on DZero results at ~300 fb^{-1}
- Scaled to higher luminosities
- Bands indicate 10% variation of events





SUSY AT THE LHC

- **Will generally be found fast!**
- **But SUSY comes in very many flavours**
- **Hints from the Tevatron would help on search priorities, e.g.**
  - **tanβ large:**
    - **3rd generation important (τ's, b's)**
  - **R-parity is violated**
    - **No E_T**
  - **GMSB models:**
    - **Photons important**
  - **Split-SUSY:**
    - **Stable charged hadrons**
  - **Can setup triggers accordingly**